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XII

PELAGIC MAMMALS FROM THE TEMBLOR FORMATION OF THE KERN RIVER REGION, CALIFORNIA

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This paper presents the results of studies on fossil pelagic mammals from the Temblor formation which outcrops on a hill southwest of Round Mountain, locally known as Sharktooth Hill, and about seven miles northeast of Bakersfield, four miles east of the Kern River Oil Field, and a quarter of a mile north of Kern River, Kern County, California. This hill is located in Sec. 25, T. 28 S., R. 28 E., M. D. M., and is shown but not named on the Caliente sheet of the United States Geological Survey's topographic map. The greater part of the material studied belongs to the California Academy of Sciences and was assembled largely through the active interest of Messrs. Paul Shoup and M. E. Lombardi. To. Dr. Barton Warren Evermann and Dr. G. Dallas Hanna, the writer is indebted for permission to study the collection.

Prior to the assembling of this collection, several smaller lots, obtained by Mr. Charles Morrice, were presented to the United States National Museum. Detailed descriptions of specimens in both of these collections are herewith given. Through the cooperation of the Carnegie Institution of Washington, arrangements were made for transporting the Academy's collection to Washington, D. C., and that organization provided additional funds for illustrating the more im-

portant specimens. For carrying out the latter purpose, the services of Mr. Sydney Prentice were secured, and he has prepared the line drawings that accompany this report.

Excavations made on Sharktooth Hill in 1924 under the direction of Doctor Hanna and Mr. Morrice, yielded something like a thousand bones, the majority of which were so damaged and imperfectly preserved that they were discarded. Most of the bones are more or less incrusted with a psilomelate of manganese. They occur in a fairly coarse, light gray, firm sandstone, and it is rather surprising that so many of them were broken prior to excavation. No associated skeletons were found, and it would seem that the skeletal elements were disassociated prior to their being covered with the sediments in which they are now found. No satisfactory explanation of the conditions that led to the accumulation of these bones has as yet been set forth. According to Doctor Hanna[1] "the bones occupy a stratum not over three feet thick so that the extinction of the excessively abundant species must have occurred in a very short time. The wide extent of the deposit does not indicate that the animals were trapped in a narrow bay as sometimes happens today with whales and sharks." Dr. F. M. Anderson[2] has suggested that an epoch of violent volcanic activity and fall of ash may have been responsible for the death of large numbers of pelagic animals in the Temblor Sea, but such an explanation does not satisfactorily account for the scattering and mingling of bones of many species of animals. Under such conditions one would expect to find complete. associated skeletons buried in ash and other sediments in the positions in which they perished. Poisonous volcanic gases and inorganic materials may have caused the death of the Temblor animals, but some agency other than volcanic activity must have been responsible for scattering the remains. It is possible that the conditions of deposition at the Sharktooth Hill locality may have paralleled present conditions near Surf, California. The rush of the water at that locality would tear any skeleton apart. Critical study of this collection has led the writer to believe that some of the bones may have decayed before fos-

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[1] G. D. Hanna, Miocene marine vertebrates in Kern County, California. <Science, n. s., vol. 61, no. 1568, pp. 71-72, January 16, 1925.

[2] F. M. Anderson, The Neocene Deposits of Kern River, California. <Proc. Calif. Acad. Sci., Ser. 4, vol. 3, p. 102, 1911.

silization took place. From this it may be inferred that the bones were washed about before they were finally covered with sediments. Bones of cetaceans are usually quite porous and the cavities are filled with small globules of oil. Bacteria and other organisms thrive in these bones and under certain conditions disintegration results. On the other hand, bones of pinnipeds are generally less porous than those of cetaceans and this may account for their better preservation. Unusually large numbers of sharks abounded in the Temblor Sea and pelagic mammals undoubtedly suffered from their predatory proclivities. The skeletons of their prey would be dismembered and the bones scattered. Nevertheless, teeth of sharks are by far the most abundant fossil remains found at this locality, and it would seem that they perished in enormous numbers at about the same time as the pelagic mammals. Further study of the Temblor formation, particularly the bone bed, may lead to some rational explanation of the conditions that resulted in the accumulation of this varied fauna at one particular level in the formation. The fact that many of the bones are fractured and the cavities filled with gypsum would seem to indicate violent diastrophic activity subsequent to their burial, and that the resulting cracks were later cemented by the salts carried in solution by percolating water.

This bone bed is included in Anderson's zone "C," but it is not the uppermost fossil horizon, for above it lies a poorly preserved fauna of invertebrates, and below it are the very fossiliferous strata from which were obtained most of the Temblor mollusca described by Anderson and Martin. Likewise below there is a widespread zone of diatomite and several zones of characteristic foraminifera. The bone bed is located a short distance below the unconformity which in the Kern River region separates strata of uncertain age, known as the "Kern River Group," from the underlying Temblor formation. The beds dip to the westward at an angle of about 5 degrees, and the strike is approximately north and south.[2a]

The Temblor fauna includes primitive whalebone whales (cetotheres), delphinoid porpoises, a squalodont, a sperm whale, two pinnipeds, *Desmostylus*, a sea turtle allied to the

[2a] For an account of the geology of the region see: G. D. Hanna, Geology of Sharktooth Hill. Proc. Calif. Acad. Sci., ser. 4, vol. 19, 1930, pp. 65-83, 3 text figs.

recent green turtle, and at least three birds.[2b] So little is known in regard to the geological history of the pinnipeds that they must be disregarded for purposes of time correlation. Nevertheless, *Allodesmus* is quite distinct from the sea lion of the diatomaceous series at Lompoc and unquestionably represents a more generalized type, while the Lompoc animal corresponds rather closely in most details with the recent *Eumetopias*. The peculiar pelagic *Desmostylus* and the cetotheres correspond in specialization with other types found elsewhere in Miocene formations, but the sperm whale is quite unlike any other described physeteroid. It is also true that none of the long beaked porpoises of the Miocene are represented in the material thus far collected, but one of the contemporary squalodonts is present. The delphinoid porpoises add little information in regard to the age of this deposit. Although our present limited knowledge of these animals adds very little conclusive evidence in regard to the age of the Temblor formation, it is unquestionably the largest fauna of pelagic mammals thus far known for any Tertiary formation on the Pacific Coast of North America. There is some slight evidence in favor of regarding the Temblor fauna as of middle Miocene age. In the cast of cetaceans, we are dealing with a type of specialization which shows the cumulative effects of modification, and the telescoping of the bones in the skull affords a means of determining the stage in their general advance. The stages represented by the Temblor cetothere skulls and the physeterid skull are what we should expect to find in middle Miocene formations.

Toward the close of the Oligocene and in early Miocene times, we find a few survivals of archaic types, but the bulk of the cetaceans are more advanced than their predecessors. There are, in the lower Miocene, at least five recognizable families of toothed whales which are known as squalodonts, long beaked porpoises, short beaked porpoises, beaked whales, and sperm whales. The whalebone whales are represented by the cetotheres and a primitive balænid. A wider diversification of the prevailing types seems to characterize the middle Miocene faunas. On analyzing the late Miocene faunas, we note

[2b] For a description of these birds see: A. Wetmore, Fossil bird remains from the Temblor formation near Bakersfield, California. (Proc. Calif. Acad. Sci., ser. 4, vol. 19, no. 8, 1930, pp. 85-93, 7 text figs.)

a perceptible reduction in the number of long beaked types, the disappearance of the squalodonts, the appearance of advanced types of beaked whales (ziphioids), the appearance of the larger, modernized whalebone whales, and a tendency toward the elimination of the true cetotheres. In Europe and elsewhere, we observe that these modernized types make their appearance toward the close of the Miocene period, coincident with the reduction and extinction of the types that preceded them. In the diatomaceous series at Lompoc, California, a more modernized assemblage than that of the Temblor makes its appearance, and the writer is inclined to refer that fauna to the later part of the Miocene. During the Pliocene, typical whalebone whales become more numerous, the short beaked porpoises are similar to living types, the beaked whales (ziphioids) belong to living genera, and, in the early Pliocene Parana formation of South America, a few new types of long beaked porpoises represent the only known survivors of that line of development.

Order SIRENIA

Suborder Desmostyliformes Hay, 1923

Family DESMOSTYLIDÆ Osborn, 1910

The peculiar pelagic *Desmostylus* has been found at quite a number of localities in formations of Miocene age. This genus in its restricted sense makes its first appearance on the Pacific Coast in the lower Miocene Vaqueros formation of southern California, and is known to have survived until nearly the close of the upper Miocene, for teeth of *Desmostylus* have been found in the San Pablo group of California. Species with similarly constructed teeth have been found in Japan at a number of localities of middle Miocene age, but the Japanese teeth, in so far as one can judge from casts, are smaller than the teeth that have been found in Oregon, in the Montesano formation of Washington, and in the Temblor and San Pablo formations of California. Teeth found in the Sooke formation of Vancouver Island, British Columbia, possess the unmistakable peculiarities of the *Desmostylus* group, and have been referred to the genus *Cornwallius* by Dr. O. P.

Hay. Teeth of this type have not certainly been identified except in formations of unquestionable Miocene age.

The relation of this interesting pelagic mammal to other groups of mammals has occasioned considerable comment in technical journals and elsewhere. The structure of the skull of *Desmostylus* has been interpreted by Marsh, Merriam, Hay, and Matsumoto as demonstrating some degree of affinity to the Sirenia. Osborn, Yoshiwara and Iwasaki, and Matsumoto have discussed the supposed resemblances to the Proboscidea. More recently, Abel has come to the conclusion that *Desmostylus* is not a placental mammal, but a multituberculate (Allotheria). The basis for this surprising conclusion rests largely on the supposed relations between the jugal bone and the zygomatic arch. The jugal, according to Abel's belief, is excluded from the lower border of the zygoma by the backward prolongation of the maxillary to the glenoid fossa. Doctor Hay has described in detail the actual relations of these bones, and he reached conclusions which are opposed to those set forth by Professor Abel.

Our present knowledge of the cranial characteristics of this peculiar mammal is limited to a fairly well preserved skull of a supposedly immature individual of *Desmostylus cymatias,* found in Oregon, which measures 310 mm. in length, and the skull of a somewhat larger individual of *Desmostylus japonicus,* found in the province of Teshio, Japan, and measuring 550 mm. in length. The Oregon skull lacks the extremity of the rostrum and the Japanese skull lacks most of the braincase. It has been estimated by Matsumoto that the Oregon skull when complete would measure about 380 mm. in length and the Japanese skull about 900 mm.

Differences in the size and proportions of the cheek teeth as well as in the number of pillars have led to the description of four species of *Desmostylus*. The characters that distinguish these species are susceptible of more than one interpretation. Greatly worn teeth differ markedly from unworn teeth and the present uncertainty in regard to the validity of the several species is likely to exist until the complete dentition of the upper and lower jaws of one or more of the North American forms is described and figured. For the present, the writer is not inclined to be too positive in regard to the allocation of

some of the teeth that have been found and described. Pertinent citations together with lists of localities for the four species that have been described are herewith given.

Genus **Cornwallius** Hay, 1923

1. **Cornwallius sookensis** (Cornwall)

Desmostylus sookensis CORNWALL, Canadian Field Naturalist, vol 36, 1922, p. 121, text figs. 1-4.—CLARK & ARNOLD, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 14, no. 5, 1923, pp. 177-178, pl. 39.

Cornwallius [*sookensis*] HAY, Pan-Amer. Geol., vol. 39, March, 1923, p. 107, text fig. 4.

Cornwallius sookensis HAY, Proc. U. S. Nat. Mus., vol. 65, publ. 2521, 1924, pp. 1-8, pls. 1-2, text fig. 1.

Type locality: Sooke formation, cliffs between Muir and Kirby creeks, Vancouver Island, British Columbia.

Genus **Desmostylus** Marsh, 1888

2. **Desmostylus cymatias** Hannibal

Desmostylus hesperus HAY, Proc. U. S. Nat. Mus., vol. 49, publ. 2113, 1915, pp. 381-397, pls. 56-58.—ABEL, Acta Zool., häft 2-3, arg. 3, 1922, pp. 361-394, pls. 1-3, text figs. 5.—ABEL, Sitzungsber. kais. Akad. Wiss., Wien, 1922, pp. 1-3.—HAY, Pan-Amer. Geol., vol. 39, 1923, pp. 105-109.—HAY, Proc. U. S. Nat. Mus., vol. 65, publ. 2521, 1924, pp. 2-8, text fig. 2, pl. 1, fig. 3.—ABEL, Verhandl. Zool.-Bot. Gesell., Wien, bd. 74/75, 1926, pp. 134-138.—ABEL, *in* M. Weber, Die Säugetiere, bd. 2, Syst. Teil, 1928, p. 44, text figs. 13-14.

Desmostylus cymatias HANNIBAL, Journ. Mammalogy, vol. 3, no. 4, 1922, p. 239, pl. 11, figs. 1-2.

Type locality: Temblor formation (according to H. G. Schenck), at mouth of Spencer Creek, Lincoln County, Oregon. [No. 8181, Division of Vertebrate Paleontology, United States National Museum.]

3. **Desmostylus californicus** Hay

Desmostylus hesperus HANNIBAL, Journ. Mammalogy, vol. 3, no. 4, 1922, pp. 238-239, pl. 12, figs. 8-9.

Desmostylus californicus HAY, Pan-Amer. Geol., vol. 39, 1923, p. 106.

Type locality: San Pablo formation, Monument Peak near San Jose, Santa Clara County, California.

Reported from: (1) A number of teeth, bones, and fragments of tusks found in shell limestone intercalated with the lower or buff sandstone member of the San Pablo formation on the San Jose Quadrangle, between Monument Peak and the saddle where the road to Calaveras Valley crosses the first ridge of the Diablo range; (2) at a horizon only a few hundred feet higher, a tooth was found in shell limestone about a half a mile south of the saddle where the road to Mount Hamilton crosses the first ridge; and (3) a fragment of a *Desmostylus* tooth, also found in a mixture of limestone and rhyolite tuff interbedded with Monterey shale, on the New Almaden Quadrangle northeast of the Guadalupe quicksilver mines, and associated with *Pecten andersoni* Arnold.

4. **Desmostylus hesperus** Marsh

Desmostylus hesperus Marsh, Amer. Journ. Sci. and Arts, vol. 135, 1888, pp. 94-96, text figs. 1-3.—Merriam, Science, n. s., vol. 24, 1906, p. 151.—Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, no. 18, 1911, pp. 403-412, text figs. 1-3.—Merriam, Trans. Amer. Philos. Soc., n. s., vol. 22, 1915, pp. 13-14, text figs. 21a, 21b.

Type locality: Monterey series *(fide* Hay, 1923, p. 106), Contra Costa County, California *(fide,* Merriam, 1911, p. 404).

Reported from: Monterey formation north of Coalinga, N. W. ¼ of Sec. 29, T. 18 S., R. 15 E., Big Blue Hills, Fresno County, Coalinga Quadrangle, U. S. G. S.; Vaqueros [Temblor] formation in Canoas Cañon, Fresno County, Sec. 33, T. 22 S., R. 16 E., Cholame Quadrangle, U. S. G. S.; Temblor horizon in region of Devil's Den on west side of San Joaquin Valley, Kern County, T. 25 S., R. 18 E., Cholame Quadrangle, U. S. G. S.; Temblor horizon on east side of San Joaquin Valley in Kern River region; shales and sandstones of supposedly Vaqueros formation in San Luis Obispo County; shale and sandstone, supposedly Vaqueros, about 6 miles northeast of Santa Ana, Orange County, Corona Quadrangle, U. S. G. S.

5. **Desmostylus japonicus** Tokunaga & Iwasaki

Desmostylus japonicus YOSHIWARA & IWASAKI [New Fossil Mammal], Journ. Coll. Sci. Imp. Univ. Tôkyo, vol. 16, art. 6, 1902, pp. 1-13, pls. 1-3, text figs. 4.

Desmostylus sp. MERRIAM, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, no. 18, 1911, pp. 406-412, text figs. 4-11.

Desmostylus japonicus TOKUNAGA & IWASAKI, Journ. Geol. Soc. Tokyo, vol. 21, 1914, p. 33.—MATSUMOTO, Sci. Reports Tohôku Imp. Univ., ser. 2, 1918, Geol., vol. 3, no. 2, pp. 61-74, pl. 22, figs. 1-3.

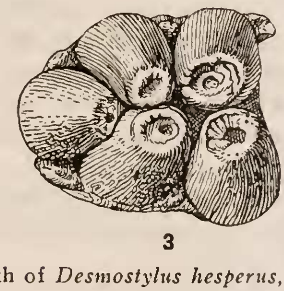
Desmostylus watasei HAY, Proc. U. S. Nat. Mus., vol. 49, publ. 2213, 1915, p. 396.

Type locality: Tufaceous sandstone, at Togari in Kanigori, Province of Mino, Japan.

Reported from: Togari [= type locality], Yamanouchi, and Tsukiyoshi, Toki District, Province of Mino; Yumachi, Province of Izumo; Yuda and Shikonai, Ninohe District, Province of Mutsu; a tributary of the Opiraushibets, Province

1

2



3

Left upper molar tooth of *Desmostylus hesperus*, No. 4401, C. A. S., × 0.5. Fig. 1. Internal view. Fig. 2. External view. Fig. 3. Occlusal view.

of Teshio, Hokkaido; and Toshibets, Province of Shiribeshi, Hokkaido [Matsumoto, 1918, p. 73].

The Temblor tooth (No. 4401, C. A. S.), hereinafter described, is fully as large as one with nine pillars recently found by Ray E. Matthews in a railroad cut near Vesta, Grays Harbor County, Washington. This last mentioned tooth and other bones in the possession of Mr. Matthews, were described in a letter written by Rev. J. Herbert Geoghegan to Dr. O. P. Hay, as having been found in what appeared to be concretions of gray sandstone or well cemented mud in a stratum composed of red sandstone and gravel. This deposit was considered to be a part of the upper Miocene Montesano formation. The length of this tooth is given as 3½ inches and the height as 3 inches. The greatest length of the incomplete Temblor tooth is 72 mm.; maximum width, 59.5 mm.; height of tooth at level of posterior pillar, 68.5 mm.; and greatest height at level of anterior pair of pillars, 81.3 mm. It is thus apparent that teeth of large size and similar configuration are found in formations varying in age from lower to upper Miocene. The proportions of the adult teeth of the Oregon *Desmostylus cymatias* are unknown, and, for the present, it seems advisable to refer the Temblor tooth tentatively to *Desmostylus hesperus*.

That this tooth (fig. 3) originally consisted of more than five high columns or pillars is shown by the broken border at one end of the base. When the tooth was complete there were at least three pairs of pillars in addition to the single posterior pillar, and one or more at the anterior end. The root is missing, and the exposed smooth surface of the dentine at the base of the crown, as viewed from below, exhibits a general resemblance to that of a mastodon. Beneath the core of each pillar is a deep conical pulp cavity, and these cavities are separated by a median longitudinal ridge. The end pillar (fig. 2) is somewhat shorter than the others and is closely appressed to the succeeding pair, but all five of these columns are nearly circular in cross section. The paired pillars curve upward and inward to the median longitudinal axis and have their apices in contact with their opposites.

Each of these pillars is covered with a rather thick outer enamel layer which is with difficulty distinguished from the

thicker concentric layers of dentine. This tooth is relatively unworn, and hence the crowns of the pillars have a thick enamel rim inclosing a small central pit whose floor is the tip of the central dentine core. The outer surface of the enamel layer is quite rugose. This tooth does not have a distinct cingulum at the base of the crown, but, nevertheless, a small irregular nodosity covered with rugose enamel projects upward from the base between each of the pillars. With wear, the circumference of the central pulp cavity increases until in a badly worn tooth the diameter may be thrice the combined thickness of the outer enamel and dentine rings.

Order PINNIPEDIA

Family ALLODESMIDÆ Kellogg, new family: Extinct Eared Seals

6. **Allodesmus kernensis** Kellogg[3]

Skeletal elements of several individuals, and representing old and young, and possibly both sexes, of this fossil Temblor otariid, are included in the collections made by Charles Morrice. The major portion of the material which has been put at the writer's disposal belongs to the California Academy of Sciences, but additional specimens were found in a small collection presented several years ago to the United States National Museum by Mr. Morrice. This material adds considerably to our knowledge of the morphological history of the Otariidæ and especially of the limb structure.

After carefully considering all the evidence, the writer is unwilling to propose one or more new names based on doubtfully distinct bones, yet this disposition of the material is not, however, made without grave misgivings that the reasons for allocating some of the skeletal elements to this fossil pinniped are unsound. There are obvious differences in some of the carpal and tarsal elements, particularly in the scapho-lunar, calcaneum, and cuboid bones. In reviewing the skeletal elements it will be observed that the fore and hind limbs do not differ materially from those of living otariids, either in the

[3] R. Kellogg, Pinnipeds from Miocene and Pleistocene deposits of California. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 13, no. 4, 1922, pp. 26-44.

proportions of their component parts or in their articular relations. There are minor differences in the vertebral column, but the sternum and pelvis exhibit the typical otariid characteristics. The mandible is not materially unlike that of the living otariids, but the skull possesses some anomalous features, of which the backward and outward extension of the premolar-molar series toward the anterior end of the zygoma is probably the most striking. The present material tends to confirm the geological antiquity of the otariid stock, but the source and time of its divergence from terrestrial relatives remain unsettled. The various skeletal elements, which are referred to this pinniped, are herewith listed.

Large Individuals— (?) Old Males

Left scapula (No. 11857, U. S. N. M.), incomplete.
Left humerus (No. 11858, U. S. N. M.), distal end only.
Left radius (No. 4292, C. A. S.), distal end missing.
Right ulna (No. 4336, C. A. S.), distal epiphysis only.
Left ulna (No. 4335, C. A. S.), distal epiphysis missing.
Right scapho-lunar (No. 11859, U. S. N. M.), eroded.
Right scapho-lunar (No. 4332, C. A. S.), eroded.
Left magnum (No. 11860, U. S. N. M.), complete.
Left metacarpal I (No. 4466, C. A. S.), proximal end only.
Left metacarpal II (No. 4478, C. A. S.), eroded.
Right metacarpal II (No. 4481, C. A. S.), proximal end only.
Left metacarpal V (No. 4480, C. A. S.), proximal end only.
Phalanx (No. 4476, C. A. S.), proximal end slightly eroded.
Phalanx (No. 4477, C. A. S.), proximal end slightly eroded.
Phalanx (No. 4479, C. A. S.), proximal end slightly eroded.
Right femur (No. 4294, C. A. S.), complete.
Left femur (No. 4295, C. A. S.), internal condyle damaged.
Right tibia (No. 4302, C. A. S.), both epiphyses missing.
Left tibia (No. 4303, C. A. S.), distal epiphysis missing.
Left tibia (No. 4494, C. A. S.), distal epiphysis only.
Left fibula (No. 4305, C. A. S.), complete.
Left patella (No. 4328, C. A. S.), complete.
Right patella (No. 4329, C. A. S.), complete.
Left patella (No. 11655, U. S. N. M.), complete.
Left patella (No. 4326, C. A. S.), complete.
Left calcaneum (No. 4309, C. A. S.), complete.
Right calcaneum (No. 4310, C. A. S.), tuberosity damaged.
Left astragalus (No. 4308, C. A. S.), complete.
Left navicular (No. 4321, C. A. S.), complete.
Left cuboid (No. 4319, C. A. S.), complete.

Right cuboid (No. 4318, C. A. S.), postero-internal angle of distal face missing.
Left entocuneiform (No. 4323, C. A. S.), complete.
Right entocuneiform (No. 4324, C. A. S.), complete.
Left entocuneiform (No. 4322, C. A. S.), complete.
Right metatarsal V (No. 11861, U. S. N. M.), proximal end only.
Right innominate bone (No. 4360, C. A. S.), distal half missing.
Atlas (No. 4398, C. A. S.), nearly complete.
Atlas (No. 4414, C. A. S.), incomplete.
Fifth cervical (No. 4407, C. A. S.), incomplete.
Sixth cervical (No. 4399, C. A. S.), nearly complete.
Sixth cervical (No. 4408, C. A. S.), incomplete.
First dorsal (No. 4412, C. A. S.), incomplete.
Fourth (?) dorsal (No. 4417, C. A. S.), incomplete.
Fifth (?) dorsal (No. 4416, C. A. S.), incomplete.
Posterior dorsal (No. 4421, C. A. S.), incomplete.
Sternal segments (Nos. 4403, 4405, 4430, 4404, 4429, 4402, 4428, C. A. S.).
Left mandible (No. 4395, C. A. S.), posterior end missing.
Right mandible (No. 4426, C. A. S.), incomplete.
Left mandible (No. 4486, C. A. S.), both ends missing.
Left maxillary fragment with canine (No. 4396, C. A. S.).
Right maxillary fragment with canine (No. 4397, C. A. S.).
Many teeth (Nos. 4580 to 4596, C. A. S.).

Individuals of Medium Size—Females or Young Males

Right humerus (No. 4337, C. A. S.), proximal epiphysis and distal end missing.
Right humerus (No. 4338, C. A. S.), distal end only.
Left radius (No. 4293, C. A. S.), proximal end only.
Right radius (No. 4291, C. A. S), proximal end only.
Right radius (No. 11863, U. S. N. M.), proximal end only.
Right radius (No. 4292, C. A. S.), fairly complete.
Right radius (No. 11866, U. S. N. M.), distal end only.
Right scapho-lunar (No. 4369, C. A. S.), angle eroded.
Right scapho-lunar (No. 4334, C. A. S.), eroded.
Right unciform (No. 11862, U. S. N. M.), slightly eroded.
Left trapezium (No 4331, C. A. S.), complete.
Left metacarpal I (No. 4465, C. A. S.), proximal end only.
Left metacarpal I (No. 11864, U. S. N. M.), proximal end only
Right metacarpal III (No. 4463, C. A. S.), complete.
Left metacarpal III (No. 4462, C. A. S.), proximal end only.
Left metacarpal III (No. 4459, C. A. S.), complete.
Left metacarpal III (No. 4460, C. A. S.), complete.
Left metacarpal III (No. 4461, C. A. S.), complete.
Right metacarpal IV (No. 4458, C. A. S.), distal end damaged.
Right metacarpal V (No. 4451, C. A. S.), slightly eroded.
Right metacarpal V (No. 4467, C. A. S.), slightly eroded.

Phalanx (No. 4468, C. A. S.), distal end missing.
Phalanx (No. 4469, C. A. S.), complete.
Phalanx (No. 4470, C. A. S.), slightly eroded.
Phalanx (No. 4471, C. A. S.), distal end missing.
Phalanx (No. 4472, C. A. S.), complete.
Phalanx (No. 4473, C. A. S.), complete.
Phalanx (No. 4474, C. A. S.), complete.
Phalanx (No. 4475, C. A. S.), complete.
Phalanx (No. 4482, C. A. S.), complete.
Right femur (No. 4299, C. A. S.), proximal end only.
Left femur (No. 4301, C. A. S.), distal end only.
Right femur (No. 4298, C. A. S.), distal end only.
Right femur (No. 4491, C. A. S.), distal end only.
Right femur (No. 4296, C. A. S.), both epiphyses missing.
Left femur (No. 4297, C. A. S.), both epiphyses missing.
Left tibia (No. 4304, C. A. S.), complete.
Right tibia (No. 4492, C. A. S.), proximal end only.
Right tibia (No. 4493, C. A. S.), proximal epiphysis only.
Right patella (No. 11545, U. S. N. M.).
Left patella (No. 4327, C. A. S.).
Right patella (No. 4330, C. A. S.).
Right patella (No. 4325, C. A. S.).
Right calcaneum (No. 11540, U. S. N. M.), complete.
Right calcaneum (No. 11589, U. S. N. M.), complete
Right calcaneum (No. 4312, C A. S.), eroded
Right calcaneum (No. 4314, C. A. S.), eroded.
Left calcaneum (No. 4313, C. A. S.), distal extremity damaged.
Left calcaneum (No. 4315, C. A. S.), eroded.
Right astragalus (No. 4306, C. A. S.), complete.
Left astragalus (No. 4307, C. A. S.), tibial face damaged.
Left astragalus (No. 11541, U. S. N. M.), complete.
Left astragalus (No. 4311, C. A. S.), damaged.
Left navicular (No. 11551, U. S. N. M.), complete.
Left navicular (No. 11550, U. S. N. M.), complete.
Right entocuneiform (No. 11546, U. S. N. M.), complete.
Left cuboid (No. 4317, C. A. S.), eroded.
Right cuboid (No. 4316, C. A. S.), complete.
Right cuboid (No. 4320, C. A. S.), eroded.
Left metatarsal II (No. 4452, C. A. S.), proximal end only.
Left metatarsal II (No. 4454, C. A. S.), proximal end damaged.
Left metatarsal II (No. 4453, C. A. S.), eroded.
Right metatarsal II (No. 4456, C. A. S.), incomplete proximal end only.
Right metatarsal II (No. 4457, C. A. S.), incomplete proximal end only.
Right metatarsal II (No. 4455, C. A. S.), eroded.
Left metatarsal III (No. 4450, C. A. S.), distal end missing.
Right metatarsal IV (No. 4448, C. A. S.), complete.
Left metatarsal IV (No. 4449, C. A. S.), distal end missing.
Right metatarsal V (No. 11870, U. S. N. M.), proximal end only.

Right metatarsal V (No. 4446, C. A. S.), eroded.
Right metatarsal V (No. 4447, C. A. S.), eroded.
Atlas (No. 4484, C. A. S.), right and left halves.
Third cervical (No. 4409, C. A. S.), incomplete.
Fourth cervical (No. 4410, C. A. S.), incomplete.
Fifth cervical (No. 4411, C. A. S.), incomplete.
First dorsal (No. 4418, C. A. S.), incomplete.
Second dorsal (No. 4419, C. A. S.), incomplete.
Anterior caudal (No. 4557, C. A. S.), incomplete.
Anterior caudal (No. 4558, C. A. S.), incomplete.
Anterior caudal (No. 4556, C. A. S.), incomplete.
Median caudal (No. 4554, C. A. S.), incomplete.
Median caudal (No. 4552, C. A. S.), incomplete.
Posterior caudal (No. 4550, C. A S.), incomplete.
Posterior caudal (No. 4551, C. A. S.), incomplete.
Posterior caudal (No. 4553, C. A. S.), incomplete.
Sternal segments (Nos. 4431, 4433, 4434, C. A. S.).
Right mandible (No. 4487, C. A. S.), posterior end missing.
Left mandible (No. 4488, C. A. S.), posterior end missing.
Right mandible (No. 4489, C. A. S.), anterior extremity only.
Left mandible (No. 4490, C. A. S.), anterior extremity only.
Extremity of left premaxilla with canine (No. 4427, C. A. S.).

Aside from its much larger size and the tooth modifications, the general aspect of the skull of *Allodesmus kernensis* may have resembled somewhat those of the White River Oligocene cats, *Hoplophoneus primævus* and *Dinictis felinus*, with a shortened face, short and heavy rostrum, massive mandibles, backward prolongation of superior portion of the supraoccipital, and expanded zygomatic arches. The backward prolongation of the median apical portion of the supraoccipital considerably beyond the level of the condyles, and the presence of a strong vertical median ridge, which acts as a brace for the lambdoid crest, are quite unlike the retreating curvature of the vertex of the supraoccipital in living otariids. Both *Dinictis* and *Hoplophoneus* have mandibles with a pronounced genial tuberosity, but this tuberosity is much reduced in *Allodesmus*. It is possible that *Allodesmus* may have been derived from a progenitor whose mandible had a somewhat larger genial tuberosity, but it is equally probable that the development of a genial tuberosity in *Dinictis* and *Hoplophoneus* accompanied the elongation of the canines, and that it bears some relation to the functional use of these teeth. Furthermore, in case of *Dinictis* and *Hoplophoneus*, not more than

two or three of the upper and lower premolars are present, but one upper molar remains, and the lower molars are reduced to one or two. In both of these felids, the fourth upper premolar is the carnassial, while in *Allodesmus* the upper cheek teeth appear to progressively diminish in size from the anterior to the posterior end of the series. In the mandible, the fourth premolar is the largest cheek tooth. The carnassial teeth are not differentiated in either the upper or the lower premolar-molar series. Furthermore the large canines are equally developed in the upper and lower jaws of *Allodesmus*. As with *Allodesmus,* these Oligocene cats have a consolidated scapholunar-centrale.

Patriofelis[4] from the middle Eocene of the Bridger Basin, Wyoming, has an outwardly curved premolar-molar series, so it would appear that *Allodesmus* retains some of the creodont heritage, especially in the curvature of the upper cheek teeth, the persistence of two small upper molars, and the location of the antorbital foramen at the level of Pm^4. But *Patriofelis* with its large, massive skull, shortened face, broadly and abruptly truncated rostrum, and shearing M^1 and M_2 does not seem to possess any close phylogenetic relationship with *Allodesmus*. The enlarged and powerful second lower molar, according to the general rules of probability, would not be expected to disappear in dental reduction. Furthermore, the scaphoid, lunar, and centrale are separate bones in the carpus of *Patriofelis*. The pelvis also presents a number of anatomical characters not found in *Allodesmus*.

Some of the Miacidæ[5] have an outward bowed upper molar-premolar series, especially *Miacis* and *Vassacyon*. Matthew[6] has shown that the scaphoid, lunar, and centrale are consolidated in *Vulpavus profectus,* and it is possible that the fusion of these elements may have taken place in other members of this family of creodonts. There is no available evidence to show that the consolidation of the scaphoid, lunar, and centrale has taken place since entering an aquatic environment, and, in

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[4] J. L. Wortman, Bull. Amer. Mus. Nat. Hist., vol. 6, art. 5, 1894, pp. 129-164, pl. 1, figs. 1-5.—W. D. Matthew, Mem. Amer. Mus. Nat. Hist., vol. 9, pt. 6, 1909, pp. 420-432, figs 50-52.

[5] W. D. Matthew & W. Granger. A revision of the Lower Eocene Wasatch and Wind River Faunas. Bull. Amer. Mus. Nat. Hist., vol. 34, art. 1, 1915, pp. 33-34, 41-42.

[6] W. D. Matthew, Mem. Amer. Mus. Nat. Hist., vol. 9, pt. 6, 1909, p. 388, fig. 29.

the absence of such confirmatory evidence, it would seem that the otariids were descended from terrestrial creodonts in which these carpal elements were consolidated.

Inasmuch as the carefully considered evidence assembled by Matthew[7] and Gidley[8] seemed to indicate that the clænodonts were progressing toward the Ursidæ in the distinctive characters of the teeth and feet, it was necessary to examine their possible relationships to the Otariidæ. In a more recent communication,[9] however, Doctor Matthew questions the supposed relationship between the Arctocyonidæ and the Ursidæ. In the carpus of *Clænodon* and *Neoclænodon* the scaphoid and centrale are fused, and, although the lunar-centrale facet persists, the lunar-scaphoid facet has disappeared and is replaced by a roughened bony surface. These details seem to point to the imminent union of the scaphoid and lunar.

The tarsal bones exhibit a number of distinctive features not found in any of the Otariidæ. The astragalus of *Allodesmus kernensis* differs from that of *Neoclænodon montanus* (No. 9779, U. S. N. M.) in having (1) the trochlea continued farther proximally in a plantar direction; (2) the astragalar foramen open or closed; (3) a narrow oblique groove for the flexor digitorum on the tibial border of plantar prolongation of the body, in contrast to the unusually broad groove which occupies most of the plantar prolongation of the body in *Neoclænodon;* and (4) the head less flattened and narrower from side to side.

Although the calcaneum of *Allodesmus* is quite similar in general shape to that of *Neoclænodon* (No. 8362, U. S. N. M.) it differs in having (1) a shorter stouter shaft, (2) a less proximally extended sustentacular facet, (3) a narrower distal facet for the cuboid, (4) a shallower interosseous groove between ectal and sustentacular facets, and (5) a less protuberant peroneal tubercle.

The cuboid of *Allodesmus* differs from that of *Neoclænodon* (No. 8362, U. S. N. M.) in having (1) a relatively smaller

[7] W. D. Matthew, Additional observations on the Creodonta. Bull. Amer. Mus. Nat. Hist., vol. 14, art 1, 1901, pp. 14-15.

[8] J. W. Gidley, New species of Clænodonts from the Fort Union (Basal Eocene) of Montana. Bull. Amer. Mus. Nat. Hist., vol. 41, art. 14, 1919, pp. 541-55, text fig. 10, pl. 28.

[9] W. D. Matthew, The evolution of the mammals in the Eocene. Proc. Zool. Soc. London, 1928, p. 971.

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and more convex facet for calcaneum; (2) a more oblique curvature of astragalar facet and a more reduced navicular facet; (3) a reduced proximal facet for ectocuneiform; and (4) the presence of facets on distal end for metatarsals IV and V, whereas there is but a single facet on the cuboid of *Neoclænodon.*

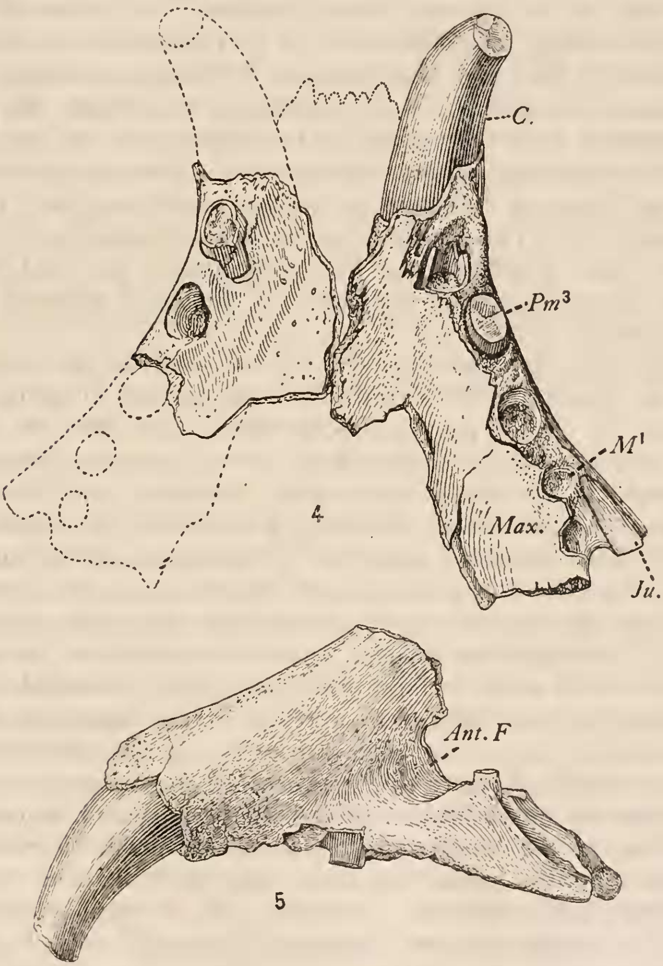
Matthew has called attention to (1) the slender, serrate, and unworn canines; (2) the reduction of the premolars; and (3) the presence of low-cusped quadrate molars, with lower M_3 somewhat reduced. The derivation of the Otariidæ from the clænodonts is beset with several obstacles, inasmuch as the clænodonts are characterized by, (1) the presence of a protuberant, outwardly curved, lesser trochanter below the head of the femur; (2) the presence of a distinct third trochanter at a lower level on the external border of the shaft; (3) the presence of an entepicondylar foramen in the humerus; (4) the fact that the upper M^2 and the lower M_3 are the largest of the cheek teeth and hence would not be expected to be reduced in the course of dental reduction; and (5) the presence of keeled, fissured, ungual phalanges, with no trace of a basal sheath.

In view of the debatable nature of the evidence which has been brought forth to support the theory of the derivation of the otariids from members of several families of creodonts, it would appear that they can not be derived from any known genus, and, in so far as some osteological characters are concerned, the Otariidæ may retain as much of the felid heritage as they do of the ursid heritage. The dentition of the Otariidæ is quite unlike either of the last mentioned groups.

The foregoing remarks are intended to supplement the summary[10] published in 1922. Nevertheless it would appear that in the progressive evolution of the otariids, (1) the facial region was deepened; (2) the spreading or outbowing of the zygomatic arches was reduced; (3) the antorbital foramen was moved backward; (4) one lower incisor was lost; (5) the first upper premolar was lost; (6) the upper and lower molars were reduced in size; (7) the premolar-molar series were moved inward with the side to side compression of the rostrum and the opposite rows became nearly parallel; (8) the notch

[10] R. Kellogg, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 13, no. 4, 1922, pp. 94-97.

between the palatal portion of the maxillary and the jugal was widened; and (9) the posterior narial gutter was closed in by the narrowing and backward prolongation of the palatal region.



Rostral fragments of the skull of *Allodesmus kernensis*, × 0.5. Fig 4. Palatal view of right and left rostral fragments, Nos. 4397 and 4396, C. A. S. Fig. 5. Lateral view of left rostral fragment, No. 4396, C. A. S.

SKULL

Portions of the rostrum of at least two and possibly three individuals are represented in this collection. Of these, a portion of the left maxillary (No. 4396, C. A. S.), with large canine, roots of Pm^2 and Pm^3, as well as the alveoli for Pm^4, M^1 and M^2, is the most nearly complete. A portion of the right maxillary (No. 4397, C. A. S.) with alveolus for canine, the root of Pm^2, and the alveolus of Pm^3 seems to belong with specimen No. 4396, C. A. S., but there is no certainty that this association is correct, since the two portions of the rostrum were in separate packages when received. There is in addition to the above, a fragment of another right maxillary (No. 4426, C. A. S.) bearing a large canine tooth and alveoli for a small Pm^1, a rather large Pm^2, and smaller Pm^3 and Pm^4. The occipital region of the skull[11] of this fossil pinniped was described in 1922.

By referring to text fig. 4, it will be seen that the rostrum of this pinniped differs from all living otariids in having an outwardly curved premolar-molar series, with Pm^4, M^1, and M^2 actually outside of the level of the antorbital foramen, whereas in the living *Eumetopias*, *Zalophus*, and *Arctocephalus*, the two series are nearly parallel and lie within the level of the antorbital foramina. That portion of the maxillary which forms the roof for the antorbital foramen is missing, but the anterior orifice of the latter lies at the level of Pm^4. Although the peculiar outward curvature of the premolar-molar series is quite unlike any living pinniped, it is obvious that the cheek teeth were not carried backward upon the anterior end of the zygomatic arch, for the small second upper molar is placed within, and anterior to, the narrow notch between the antero-inferior process of the jugal and the palatal portions of the maxillary. The number of upper incisors is unknown. The canine is a large recurved tooth, with crown covered with a thin coat of enamel. The alveolus of a small Pm^1 is present on one specimen (No. 4427, C. A. S.), but no trace of it can be found on the larger rostral fragment (No. 4396, C. A. S.). It is barely possible that this tooth may belong with the milk dentition, since it lies slightly internal to

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[11] R. Kellogg, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 13, no. 4, 1922, pp. 29-32, text figs. 2a-2b.

the much larger succeeding premolar. Assuming that this represents the alveolus of the first upper premolar, then the second upper premolar has the largest root of the premolar series and may have had a larger crown than the others. The alveoli of the cheek teeth progressively decrease in size from the anterior to the posterior end of the series. The roots of all the cheek teeth were implanted obliquely, and, with the exception of the molars, all were implanted on the outer edge of the maxillary. The almost horizontal direction of the alveolus for the small second upper molar seems to offer an explanation for the loss of this tooth by the living genus *Eumetopias*. The direction of this alveolus indicates that the tooth could hardly function in any normal manner, and hence would tend to be reduced in the course of time. The upper cheek teeth appear to consist of four premolars of which Pm^1 is usually missing, and at least two small molars. It is impossible to determine from the material at hand whether or not this form has a third upper molar.

Viewed from the side (fig. 5), the depth of the maxillary (54 mm., No. 4396, C. A. S.) at the level of the antorbital foramen is about one-half of that (98 mm., No. 7140, U. S. N. M.) of an old adult *Eumetopias jubata*. The sinuous curvature of the superior margin of the maxillary of *Eumetopias* also is quite unlike the sloping margin of the maxillary of this fossil pinniped. The premaxillary and the incisors are missing. The external narial orifice is narrower and the infraorbital portion of the maxillary is prolonged farther backward than in any living otariid.

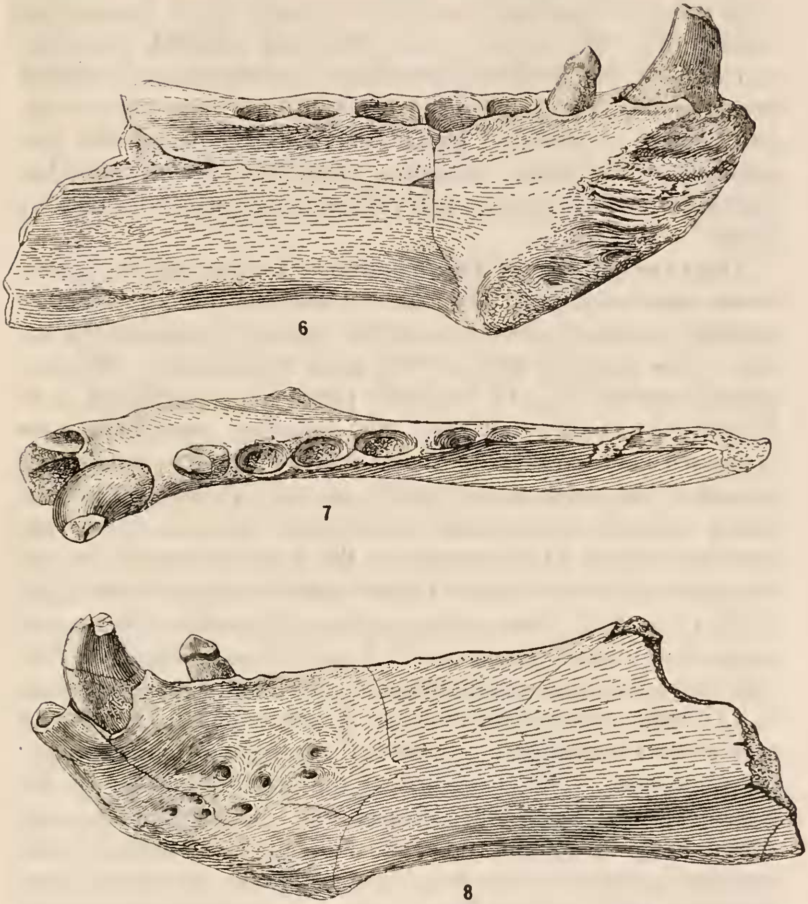
The skull of *Allodesmus* differs from that of *Eumetopias* in having (1) the premolar-molar series curving outward and ending near level of anterior end of zygomatic arch; (2) at least five functional upper cheek teeth which decrease in size from anterior to posterior end of the series; (3) a rather large second upper premolar; (4) no indication of a basirostral constriction; (5) an obvious backward prolongation of infraorbital portion of maxillary; (6) antero-inferior process of jugal extending forward to level of first upper molar; (7) a wider palate; and (8) a conspicuous lambdoid crest, with median apical portion prolonged backward.

Among the fragmentary and more or less complete teeth referred to *Allodesmus kernensis* are two molars, nine premolars, and three canines. The molars have small crowns and unusually short roots. All of the premolars have rather long roots, and many of them have a pronounced longitudinal external groove. The crowns of all these cheek teeth have the appearance of being covered with fairly smooth enamel, although on closer inspection it will be seen that it is finely pitted. With the exception of the larger premolars, all of the cheek teeth have rather low crowns, with the apical portion curving inward. The base of the crown is swollen and its circumference is greater than that of the root. Two of the larger premolars exhibit rudiments of basal nodosities at the posterointernal angle. The roots of the cheek teeth are often asymmetrical and taper irregularly, but the pulp cavity is closed. The large canines, with recurved crowns which often pass imperceptibly into the neck, have an open pulp cavity. Three teeth, with strongly recurved apices and pronounced basal rugosities on the internal face, agree sufficiently with the incisors of *Eumetopias* to be considered such. The crown is but slightly swollen at the base, and the root has a distinct neck, below which is a pronounced enlargement. The pulp cavity in the roots of these teeth is closed and the roots are asymmetrical.

MANDIBLE

Portions of seven mandibles belonging to individuals of different sizes agree with the type mandible of *Allodesmus kernensis*[12] in all their essential details. Three of these belong to large individuals and they are, respectively, a nearly complete left mandible (No. 4395, C. A. S.) ; an incomplete right mandible (No. 4426, C. A. S.) ; and a section of a left mandibular ramus (No. 4486, C. A. S.), having both ends missing. Four belong to considerably smaller individuals, possibly females or young males, and are apparently the anterior halves of the right (No. 4487, C. A. S.) and the left (No. 4488, C. A. S.) mandibles of one individual; the anterior extremity of a right

[12] R. Kellogg, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 13, no. 4, 1922, pp. 26-28, figs. 1a, 1b.



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Incomplete left mandible of *Allodesmus kernensis,* No. 4395, C. A. S., × 0.5. Fig. 6. Internal view. Fig. 7. Dorsal view. Fig. 8. External view.

mandible (No. 4489, C. A. S), and the corresponding portion of another right mandible (No. 4490, C. A. S.).

The largest of these mandibles lacks the coronoid process, the condyle, and the angular process. This left mandible (fig. 8) is approximately the same size as the type right mandible and is much more nearly complete. The canine and the first premolar are in place, and there are, in addition, alveoli for two incisors, three premolars, and two molars. As compared

with the corresponding mandible of a large adult *Eumetopias jubata* (No. 7140, U. S. N. M.) this fossil mandible is characterized by a longer and more oblique symphysis, a somewhat deeper ramus, a more posterior and shallower masseteric fossa, and a more pronounced genial tuberosity. The number and position of the mental foramina agree with *Eumetopias*, but the cheek teeth are larger, and the outer incisor is considerably larger.

The external face of the mandibular ramus (fig. 9) is flattened superiorly, but, taken as a whole, the external surface exhibits a convex curvature and the internal a concave curvature. The ramus is about as thin as in *Eumetopias*. The symphysial surface (fig. 6) is deeply pitted and corrugated as in *Eumetopias,* indicating that the opposing mandibles were appressed very closely and bound together by ligaments. The alveoli of the cheek teeth (fig. 7) are very closely spaced, the length of the lower series measuring 141 mm. from the anterior margin of the canine to the posterior border of the alveolus of the second lower molar in the largest mandible (No. 4395, C. A. S.). The antero-posterior diameter of the crown of the first lower premolar is 11.7 mm. (No. 4395, C. A. S.). The corresponding measurement of the third lower premolar is 13.6 mm. and that of the first lower molar, 11.5 mm., in another left mandible (No. 4486, C. A. S.) of approximately the same size. The curvature of the superior border of the last mentioned mandible indicates that the coronoid process slopes more gradually upward than in *Eumetopias*. The rounded crowns of the first lower premolar, the third lower premolar, and the first lower molar are covered with fairly smooth enamel. The enamel crowns of less worn cheek teeth are often finely pitted.

The available evidence indicates that *Allodesmus* is not ancestral to *Dusignathus*[13] and that the living *Eumetopias* may be a derivative of *Allodesmus*. *Dusignathus* differs from *Allodesmus* in having (1) a shorter and lighter mandibular ramus; (2) cheek teeth with larger roots, without pronounced longitudinal external groove; (3) crowns of cheek teeth with smooth, highly polished enamel in contrast to finely pitted enamel of *Allodesmus* cheek teeth; (4) loss of second lower

[13] R. Kellogg, Fossil Pinnipeds from California. Publ. 346, Carnegie Inst., Washington, 1927, pp. 27-33, text figs. 1-6.

molar; (5) more oblique slope of anterior margin of coronoid; and (6) strong convexity of lower mandibular border between genial tuberosity and lower angular process.

Measurements of Left Mandible (No. 4395, C. A. S.)

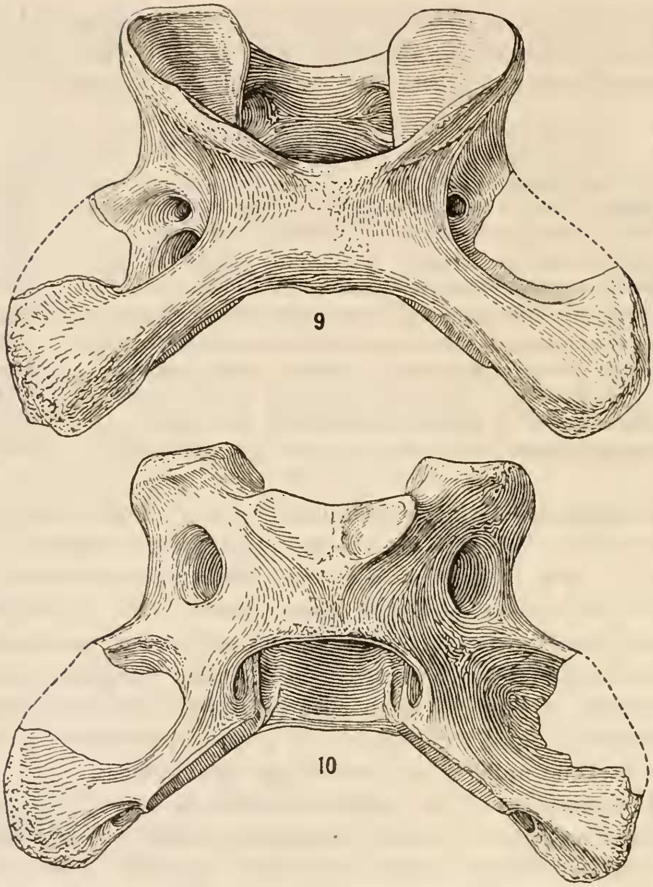
Greatest length of symphysis	106.0 mm.
Depth of ramus between fourth premolar and first molar	62.0 mm.
Antero-posterior diameter of alveolus, first incisor	12.0 mm.
Antero-posterior diameter of alveolus, second incisor	8.5 mm.
Antero-posterior diameter of alveolus, canine	32.0 mm.
Antero-posterior diameter of alveolus, first premolar	13.2 mm.
Antero-posterior diameter of alveolus, second premolar	16.4 mm.
Antero-posterior diameter of alveolus, third premolar	17.0 mm.
Antero-posterior diameter of alveolus, fourth premolar	17.8 mm.
Antero-posterior diameter of alveolus, first molar	12.2 mm.
Antero-posterior diameter of alveolus, second molar	8.0 mm.

As compared with the mandible of an old adult *Eumetopias jubata* (No. 7140, U. S. N. M.) this fossil mandible (No. 4395, C. A. S.) has: (1) a canine with a narrower root; (2) larger and more crowded cheek teeth; (3) considerably longer premolar-molar series; (4) a small second lower molar; (5) a distinct interval between the fourth premolar and the first molar; (6) cheek teeth with no indication of a cingulum or fringe of basal rugosities; (7) a more posteriorly situated inner incisor; and (8) a much larger outer incisor.

The mandibles of the smaller individuals agree in all essential details with the larger mandibular rami, but are lighter and have smaller teeth. The left mandible (No. 4487, C. A. S.) of one of these has a canine with a complete crown, which is recurved and somewhat compressed from side to side, but without any indication of anterior or posterior carinæ. The symphysis of this mandible is less pitted and less rugose than in those belonging to larger individuals.

Vertebræ

The vertebral column of an old male sea lion *(Eumetopias jubata)* is considerably larger than that of young males and old females, and it would appear from the present material that sexual dimorphism was equally well marked in *Allodesmus.* Seven cervical vertebræ belonging to a very large

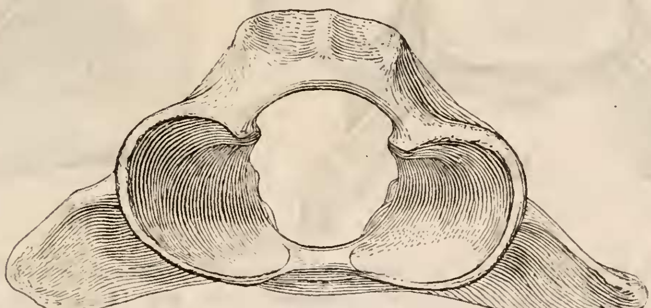


Atlas of *Allodesmus kernensis,* No. 4398, C. A. S., × 0.5. Fig. 9. Ventral view. Fig. 10. Dorsal view.

individual are referred to an old male. Unfortuntely most of these vertebræ are badly damaged. One nearly complete atlas (No. 4398, C. A. S.) and another damaged one (No. 4414, C. A. S.) show that this vertebra in *Allodesmus* differs very little from the corresponding bone in *Eumetopias jubata.* The antero-posterior diameter of the neural arch (fig. 10) is relatively greater, and the transverse processes are less incurved. The neural arch is perforated on each side by a large vertebrarterial foramen, and postero-internally on each side is the orifice of the canal that passes through the transverse process and

emerges on its internal face at a point more than half way to the extremity. The articular surface for the odontoid, as well as those for the facets on the anterior face of the centrum of axis, corresponds with that of *Eumetopias*. Not even a vestige of the neural spine is retained. The anterior articular surfaces (fig. 11) for the condyles of the skull are deep and strongly concave. The curvature of these facets is likewise similar to that in *Eumetopias*. As seen from the ventral side (fig. 9), this fossil atlas differs from that of *Eumetopias* in having transverse processes with larger fossæ through which the vertebrarterial canals pass.

The fifth cervical (No. 4407, C. A. S.) is incomplete, with both epiphyses, neural spine, and transverse processes missing. The neural arch is lower and less vaulted, but the size, shape, and direction of the pre- and post-zygapophyses agree with those in the corresponding cervical of Eumetopias. Further-



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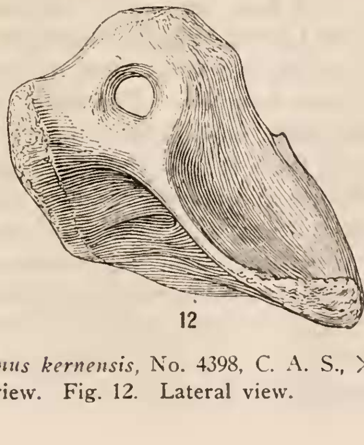

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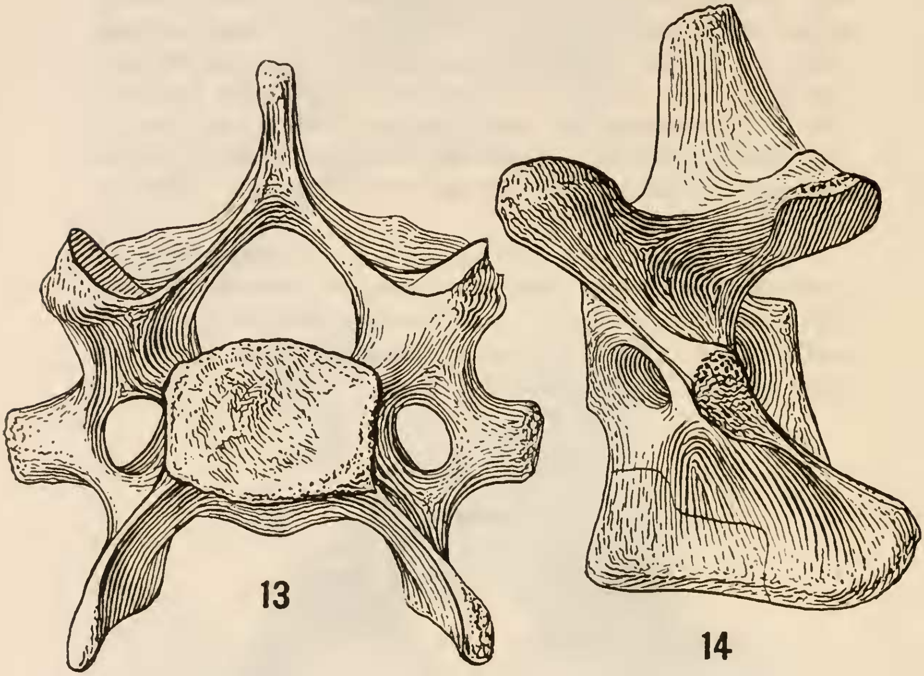
Atlas of *Allodesmus kernensis*, No. 4398, C. A. S., × 0.5. Fig. 11. Anterior view. Fig. 12. Lateral view.

more, the lateral vertebrarterial canal is slightly larger, the neural arch is much wider, and the transverse process is about three-fourths as broad at the base.



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? Sixth cervical vertebra of *Allodesmus kernensis*, restored, No. 4399, C. A. S., × 0.5. Fig. 13. Anterior view. Fig. 14. Lateral view.

Two vertebræ, which have the same structural characters as the sixth cervical of *Eumetopias*, are included in this collection. The larger of the two lacks most of its processes, but the other one is fairly complete. The latter lacks, however, both epiphyses and both diapophyses; the right postzygapophysis is missing and the left transverse process is incomplete. In general shape this fossil cervical exhibits a surprising resemblance to the sixth cervical of *Eumetopias*, but the forward inclination of the neural spine is less pronounced, the prezygapophyses are wider apart, and the postzygapophyses have more oblique articular facets. Viewed from the front (fig. 13) the neural canal is broader, the lateral vertebrarterial canals are larger, and the centrum is broader. The lateral aspect (fig.

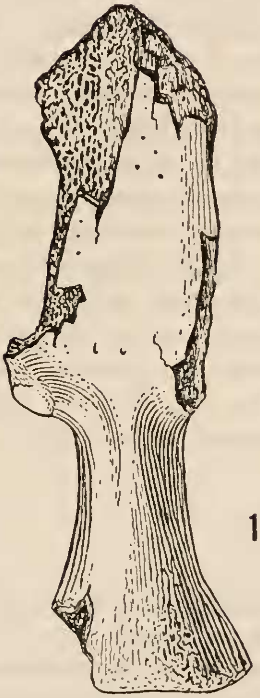
Measurements of Cervical Vertebræ (in millimeters)

	Greatest depth (vertically), tip of neural spine to inferior face of centrum	Distance across vertebra between tips of transverse processes	Distance across vertebra between tips of diapophyses	Distance across vertebra between outside margins of anterior articular facets	Least antero-posterior diameter of superior surface of neural arch	Length of centrum	Least antero-posterior diameter of neural arch	Distance between outside margins of prezygapophyses	Tip of prezygapophysis to tip of postzygapophysis
Atlas, *Eumetopias jubata*, No. 7140, U.S.N.M., ad. ♂	82.5	205.6	....	91.2	37.5	32.5	....	....	....
Atlas, *Allodesmus kernensis*, No. 4398, C.A.S.	75.5	169. +	....	102.5	38.5	33.5	....	....	....
Axis, *Eumetopias jubata*, No. 7140, U,S.N.M., ad. ♂	124.8	112.5	....	86.0	....	103.2	33.5	....	....
Axis, *Eumetopias jubata*, No. 21537, U.S.N.M.	91.8	76.4	....	72.0	....	74.0	25.0	....	....
3rd cervical, *Eumetopias jubata*, No. 7140, U.S.N.M., ad. ♂	104.2	157.0	....	....	....	76.3	43.5	89.0	104.0
3rd cervical, *Eumetopias jubata*, No. 21537, U.S.N.M.	81.3	114.7	....	....	....	58.2	34.3	70.0	86.5
3rd cervical, *Allodesmus kernensis*, No. 4409, C.A.S.	....	....	....	....	....	49.2	....	....	....
4th cervical, *Eumetopias jubata*, No. 7140, U.S.N.M., ad. ♂	109.0	136.0	161.8	....	....	77.5	37.0	95.5	105.4
4th cervical, *Eumetopias jubata*, No. 21537, U.S.N.M.	78.4	103.8	121.0	....	....	60.2	30.8	71.5	87.7
4th cervical, *Allodesmus kernensis*, No. 4410, C.A.S.	....	....	....	....	....	47.0	17.5	....	....
5th cervical, *Eumetopias jubata*, No. 7140, U.S.N.M., ad. ♂	119.0	135.4	164.9	....	....	83.5	41.4	96.2	107.8
5th cervical, *Allodesmus kernensis*, No. 4407, C.A.S.	....	....	....	....	....	....	35.7	102.2	91.8
5th cervical, *Eumetopias jubata*, No. 21537, U.S.N.M.	88.4	105.0	119.2	....	....	66.8	32.3	80.3	87.2
5th cervical, *Allodesmus kernensis*, No. 4411, C.A.S.	....	....	....	....	....	52.5	....	....	....
6th cervical, *Eumetopias jubata*, No. 7140, U.S.N.M., ad. ♂	138.8	116.8	160.1	....	....	89.5	42.0	100.0	106.8
6th cervical, *Allodesmus kernensis*, No. 4399, C.A.S.	106. +	106.0	....	....	....	....	34.5	110.8	90.9
6th cervical, *Eumetopias jubata*, No. 21537, U.S.N.M.	106.8	86.3	113.2	....	....	71.8	30.0	83.5	86.3

14) is likewise similar, but the transverse processes are much less expanded antero-posteriorly, and the centrum is relatively shorter.

The first dorsal (No. 4412, C. A. S.) is represented by an eroded centrum, and a portion of the neural arch on the right side. The centrum is much larger than that of the corresponding dorsal of *Eumetopias,* and the base of the neural arch is shorter antero-posteriorly. Three additional vertebræ are referred to this pinniped, two of which belong near the anterior end of the series and one near the posterior end. Although the first two (Nos. 4417, 4416, C. A. S.) appear to belong somewhere between the fourth and sixth cervicals, this allocation is tentative, for the centra lack posterior facets for the heads of ribs. The neural arches of these two dorsal vertebræ are quite thin, and the neural canals are rather large. The neural spines, as well as the pre- and post-zygapophyses, are missing. The centra of all three of these dorsal vertebræ are in a good state of preservation and resemble those of *Eumetopias jubata.* A dorsal vertebra (No. 4421, C. A. S.) with a long centrum and oblique prezygapophysial facets seems to belong near the posterior end of the series, judging from the vertebral column of *Eumetopias,* but there is no certainty that this allocation is correct. The neural arches are much higher than those of corresponding dorsals of *Eumetopias;* there is an eroded enlargement on the antero-lateral face of the centrum below the neural arch, in the position where the facet for the head of the rib should be located; and there is no indication of a facet for the tuberculum. The neural spine and postzygapophyses are missing, and the prezygapophyses are damaged.

Six incomplete vertebræ from much smaller individuals present peculiarities which are either attributable to age or sex. Portions of the right and left halves of the atlas (No. 4484, C. A. S.) show that this cervical has the same general shape as those of larger individuals. The facets for the odontoid process and centrum of the axis, and for the condyles of the skull are quite similar, but the anterior half of the vertebrarterial canal is closed. The third cervical (No. 4409, C. A. S.) lacks most of the neural arch, the neural spine, and all of the zygapophyses with the exception of the left prezygapophysis.



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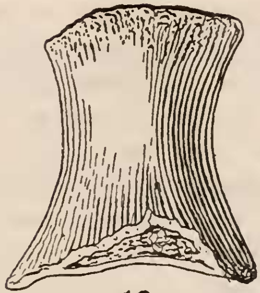

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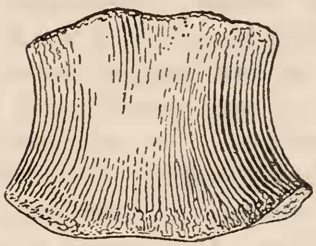

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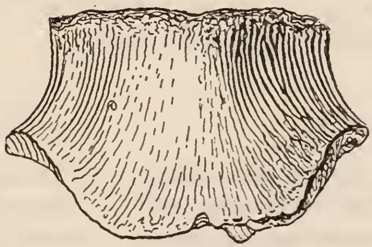

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Segments of sternum of *Allodesmus kernensis*, × 0.55. Fig. 15. Presternum, No. 4403, C. A. S. Fig. 16. First segment of mesosternum, No. 4405, C. A. S. Fig. 17. Fifth segment of mesosternum, No. 4402, C. A. S. Fig. 18. Sixth segment of mesosternum, No. 4404, C. A. S.

The centra of this and succeeding cervicals are more cylindrical than those of larger individuals, but similar sexual differences are observed in the living sea lion, and the ventral keel is well developed on all of them. The left prezygapo-

physis is placed rather low and corresponds in shape and direction to that of *Eumetopias*. The fourth cervical is likewise incomplete, the neural arch and its processes being missing. Both transverse processes lack their extremities. The fifth cervical (No. 4411, C. A. S.) lacks all of its processes with the exception of a portion of the left transverse process. The lateral vertebrarterial canal is large and the base of the diapophysis is rather narrow. The base of the transverse process is about as wide, relatively, as in larger individuals. The first dorsal (No. 4418, C. A. S.) has a centrum similar in shape to those of the cervicals, but curiously enough it retains an incompletely closed lateral vertebrarterial canal. The facet for the tuberculum of the rib is placed on the latero-inferior face of the extremity of a large process arising from the neural arch. The remainder of the neural arch and its processes are missing. The centrum is slightly eroded in spots, but otherwise quite complete, and is somewhat longer than the cervicals. The centrum of what appears to be the second dorsal (No. 4419, C. A. S.) is referred to this species. It is slightly longer than that of the first dorsal. With the exception of the lateral concavities there appears to be nothing unusual about this centrum.

Sternum

The sternum seems to have been composed of eight pieces as in *Eumetopias* and *Odobenus*. The presternum (fig. 15) is rather long and narrow, abruptly expanded near the middle for the attachment of the first pair of sternal ribs and terminating in a spatula-like anterior projection. The posterior half of the presternum tapers anteriorly to the constriction behind the point of attachment for the first pair of sternal ribs and is expanded distally. The first segment of the mesosternum (No. 4405, C. A. S.) is longer than wide and contracted mesially. The succeeding sections (Nos. 4430, 4428, 4429, 4402, 4404, C. A. S.) are broader than long. The last segment of the mesosternum (fig. 18) is expanded distally to provide a three-sided posterior face, the median one for articulation with the xiphisternum and each of the others for the

insertion of the last two sternal ribs on each side. The xiphisternum was not identified among the various miscellaneous fragmentary bones found in this collection.

Measurements of the Sternal Bones

Total length of presternum (No. 4403, C. A. S.)	164.0 mm.
Transverse diameter of posterior end of presternum (estimated)	55.0 mm.
Transverse diameter of presternum at constriction	26.0 mm.
Greatest length of first segment of mesosternum (No. 4405, C. A. S.)	69.0 mm.
Greatest length of second segment of mesosternum (No. 4430, C. A. S.)	61.0 mm.
Greatest length of third segment of mesosternum (No. 4428, C. A. S.)	57.0 mm.
Greatest length of fourth segment of mesosternum (No. 4429, C. A. S.)	58.5 mm.
Greatest length of fifth segment of mesosternum (No. 4402, C. A. S.)	56.0 mm.
Greatest length of sixth segment of mesosternum (No. 4404, C. A. S.)	57.0 mm.

Scapula

An incomplete left scapula (No. 11857, U. S. N. M.) is referred to this fossil otariid. The superior border, the posterior half of the blade, and the spine are missing. None of the living Otariidæ possess a scapula of this type. One of the most unusual peculiarities of the bone is the outward curvature of the prescapular portion of the blade. A prominent broad ridge extending upward from the neck toward the vertebral border separates the deep prescapular fossa from an obviously similar postscapular fossa. The neck of this scapula (fig. 19) is unusually long. The glenoid cavity is large, strongly concave, with its posterior diameter more than twice the width of the anterior diameter. Neither the acromion nor the coracoid process are present.

Measurements of the Scapula

Antero-posterior diameter of glenoid cavity	61.0 mm.
Greatest transverse diameter of glenoid cavity	49.+mm.
Posterior margin of broad subvertical ridge to antero-inferior angle of blade (measured at the same level)	110.0 mm.

January 30, 1931

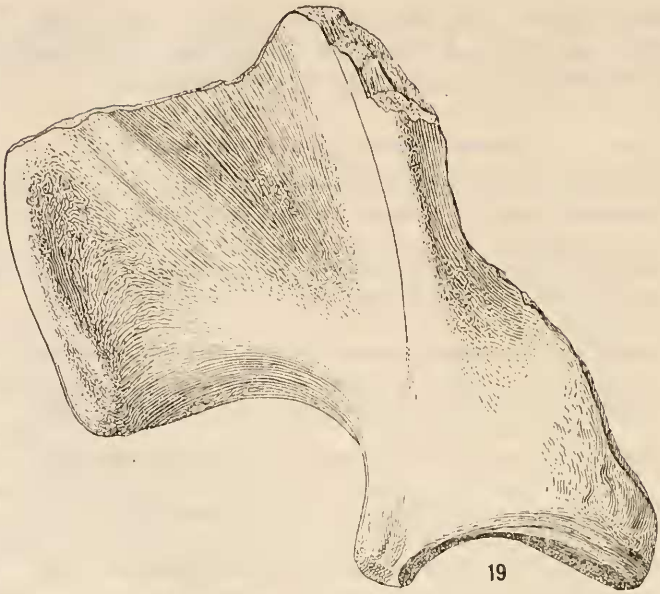


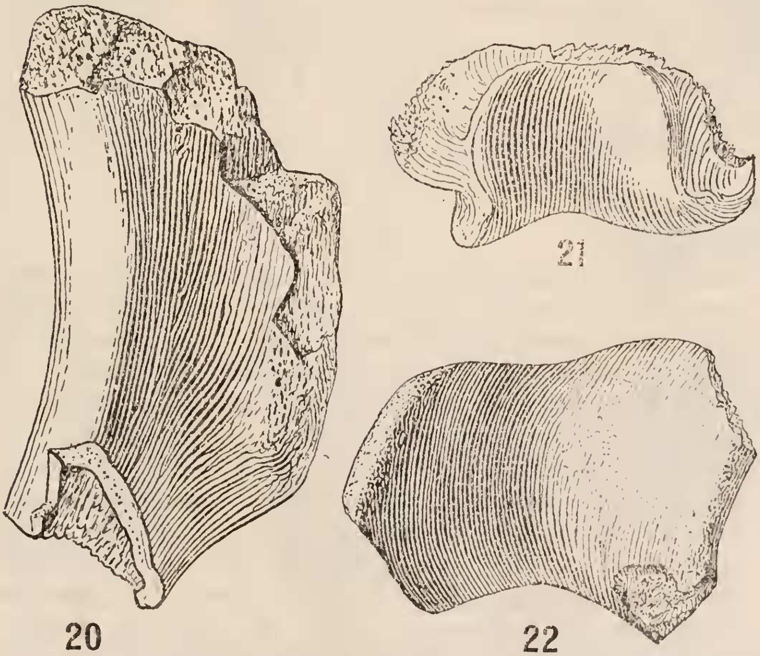
Fig. 19. Incomplete left scapula of *Allodesmus kernensis*, No. 11857, U. S. N. M., × 0.5.

Humerus

Distal and proximal fragments of a right humerus (Nos. 4337, 4338, C. A. S.), which may be portions of one bone, and the distal epiphyses of a very large left humerus (No. 11858, U. S. N. M.) are all that are known at present. The distinguishing characteristics of this fossil humerus may be summed up as follows: (1) the inner condyle is placed very low, judging from its proximity to the distal margin of the inner trochlea; (2) the anterior border of the deltoid crest does not overhang the shaft to any appreciable extent on the outer side; (3) the longitudinal ridge below the lesser tuberosity is feebly developed; (4) the transverse diameter of the posterior face at the proximal end of the shaft exceeds by one-sixth the antero-posterior diameter of the shaft below the deltoid crest; and (5) the upper portion of the shaft is rather slender in comparison to that of *Eumetopias*. The proportions of these fragments suggest a humerus of approximately the same size as that of a female or young male *Eumetopias jubata*.

Viewed from the front the shaft tapers gradually toward the distal extremity, and the proximal end is unusually narrow as compared to its length. The entire proximal epiphysis, including the head and the greater and lesser tuberosities, is missing. The deltoid ridge (fig. 20) is rather high, and, although its anterior border is somewhat eroded, there is nothing to indicate that the external margin was produced outward as in *Eumetopias*. At the distal end, the deltoid crest rises rather abruptly, and the anterior margin for most of its length is straight as viewed from the side. The posterior face of the proximal one-third curves strongly backward.

The trochlear surface (fig. 21) for articulation with the bones of the forearm is divided as usual into two main areas. The outer convex capitulum which articulates on the head of the radius, and the inner trochlea which rests in the greater



20 21 22

Fragments of humeri of *Allodesmus kernensis*, × 0.5. Fig. 20. External view proximal end of shaft of a right humerus, No. 4337, C. A. S. Fig. 21. Distal view of a right humerus, No. 4338, C. A. S. Fig. 22. Distal view of a left humerus, No. 11858, U. S. N. M.

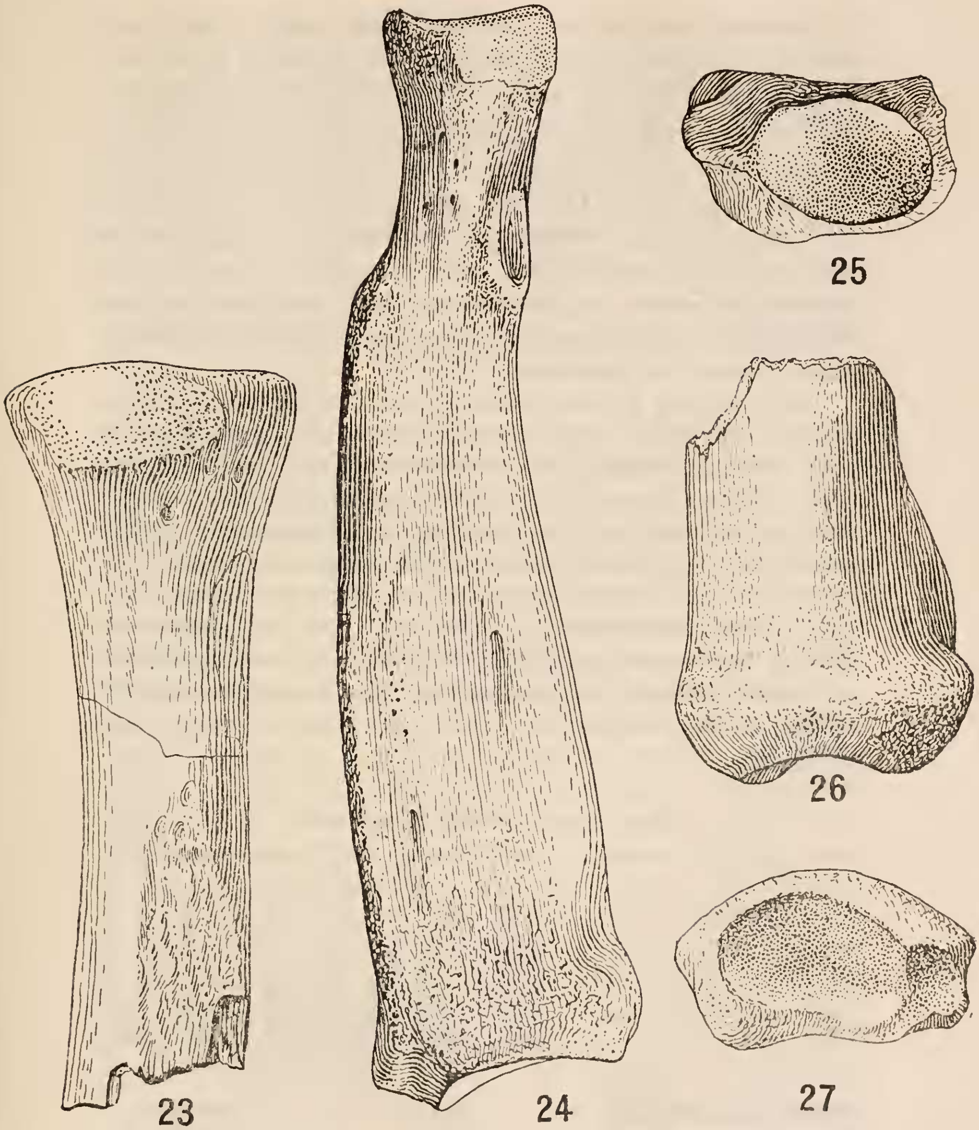
sigmoid cavity of the ulna, do not differ in any essential feature, when viewed from the front, from the corresponding surfaces of the humerus of *Eumetopias*. On the posterior face, however, the trochlea is considerably narrower. The width of the trochlear surface on the large left humerus (fig. 22) exceeds 98 mm., and thus exceeds the width of a very large old male *Eumetopis jubata*.

Measurements of Humeri (in millimeters)

	No. 11858, U.S.N.M. Left, *Allodesmus kernensis*	No. 4338, C. A. S. Right, *Allodesmus kernensis*	No. 4337, C. A. S. Right, *Allodesmus kernensis*	No. 21537, U.S.N.M. Left, *Eumetopias jubata*
Width of trochlear surface on the anterior face	97.+	73.0	....	73.5
Width of trochlear surface on the posterior face	....	51.0	....	70.8
Transverse diameter of shaft below head	....	....	55.5	91.0
Antero-posterior diameter of shaft near the middle (through deltoid crest)	....	....	68.5	74.5

Radius

In spite of their weathered and eroded condition, certain peculiarities, in addition to size which may or may not be of importance, appear to differentiate into two categories the radii represented in the material submitted for study. The writer, nevertheless, is not disposed to stress the importance of characters observed on the proximal ends of the two radii belonging to large individuals (Nos. 4293, 4406, C. A. S.) and the corresponding portions of radii of three smaller individuals (Nos. 4291, 4292, C. A. S., and No. 11863, U. S. N. M.). The heads of all these radii are more or less eroded and consequently the original contour of the proximal surface can not be determined with any degree of certainty. At the level of the bicipital tuberosity, the necks of the radii would appear subtriangular in cross section. The upper ulnar facet of one of the smaller radii (No. 4292, C. A. S.) measures 17 mm. in depth and the same measurement for one of the larger radii (No. 4406, C. A. S.) is 26.6 mm.



Radii of *Allodesmus kernensis*, × 0.5. Fig. 23. Posterior view of right radius, No. 4406, C. A. S. Fig. 24. Internal view of right radius, No. 4292, C. A. S. Fig. 25. Distal view of right radius, No. 4292, C. A. S. Fig. 26. External view of right radius, No. 11866, U. S. N. M. Fig. 27. Distal view of right radius, No. 11866, U. S. N. M.

Compared with the radii of *Eumetopias jubata,* these fossil radii are much longer and slenderer, less expanded at the level of insertion of *pronator radii teres,* and have a larger facet for distal end of ulna, a more squarely truncated anterior border of facet for scapho-lunar, and a more distal position for the bicipital tuberosity. The right radius (fig. 24) of a smaller individual is fairly complete, but the distal extremity is somewhat eroded. The distal one-third of a right radius (fig. 25) is better preserved. In addition to these two there are portions of the proximal ends of three right radii of animals of approximately the same size.

The following features seem to characterize the radius in smaller individuals: (1) the narrowness of the shaft at the level of the insertion of the *pronator radii teres;* (2) the long neck; (3) the presence of a broad depression on the posterior face of the shaft for the insertion of the interosseous ligament; and (4) the low position of the bicipital tuberosity.

On the other hand, the radius in larger individuals has: (1) a much thicker neck; (2) the large facet for the capitulum of the humerus occupying practically the entire proximal surface of the head, and the trochlear facet limited to a narrow border on the internal side; and (3) a less distinct bicipital tuberosity.

Measurements of Radii (in millimeters)

	No. 4291, C. A. S. Right, *Allodesmus kernensis*	No. 4292, C. A. S. Right, *Allodesmus kernensis*	No. 11866, U.S.N.M. Right, *Allodesmus kernensis*	No. 11863, U.S.N.M. Right, *Allodesmus kernensis*	No. 7140, U.S.N.M. Right, *Eumetopias jubata*	No. 4406, C. A. S. Right, *Allodesmus kernensis*
Greatest length of radius	......	264.0	......	......	298.0	......
Greatest diameter of radius at proximal end	54.5	54.4	......	49.5	72.5	69.3
Greatest diameter of radius at distal end	......	67.5+	72.0	......	95.0	......
Breadth of radius across bicipital tuberosity	27.0	31.0	......	32.0	42.5	......

Ulna

The left ulna (No. 4335, C. A. S.) of this pinniped is remarkable for its massiveness and for its length. It is similar in general shape to the ulnæ of *Eumetopias* and *Odobenus*, but differs from both in several important details. The greater sigmoid cavity (fig. 29) is much narrower transversely, and there is no free border on the internal and proximal sides. On an ulna of *Odobenus* and *Eumetopias* the free border of this cavity is noticeably prolonged beyond the inner and anterior surfaces of the shaft. The lesser sigmoid cavity corresponds in shape and position with that on the ulna of the walrus and sea lion.

On the internal face of the ulna (fig. 28) is an elongate depression for the flexor muscle of the digits, but this area does not extend so far distally as it does on the ulna of the walrus. Below the greater sigmoid cavity, on the anterior face of the ulna, is a rugose indentation for muscular attachment. The anterior brachialis muscle is inserted in this area on the ulna of the walrus. On the internal surface adjacent to and below this area is an elongate depression for another muscle. In case of the ulna of the walrus and the sea lion, there is a conspicuous rugose surface for muscular attachment which appears comparable to that on this fossil ulna, but it extends across the antero-internal angle of the shaft. The middle portion of the inner surface of the shaft is flattened and the distal portion is slightly concave.

The curvature of the outer face of the shaft resembles that of *Eumetopias*. The margins of the olecranon process are eroded and the proximal epiphysis is missing. The anterior border of the olecranon process of this fossil ulna is greatly thickened and the posterior border is rather thin. The shaft of the ulna attains its maximum thickness at the distal end where it would appear oval in cross section. The distal epiphysis of this ulna with its facets for the radius, pisiforme, and ulnare is lost.

Fortunately a distal epiphysis (fig. 30) of the right ulna of a smaller animal is available for comparison. The facet for the radius is considerably larger than the corresponding facet on the ulna of the walrus. The distal end of this epiphysis is produced and is furnished with a large oval facet for articula-

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Incomplete ulnæ of *Allodesmus kernensis*, × 0.5. Fig. 28. Internal view of left ulna, No. 4335, C. A. S. Fig. 29. Anterior view of left ulna, No. 4335, C. A. S. Fig. 30. Anterior view of distal extremity of right ulna, No. 4336, C. A. S.

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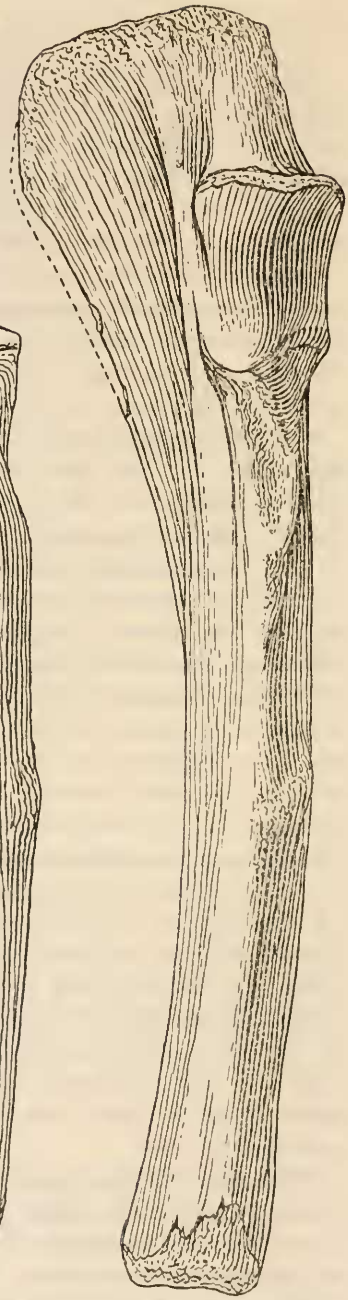

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tion with the ulnare. This facet is rather rugose and may have been covered with some sort of a capsular cartilage. Judging from the size of the irregular facet on the inner face of this epiphysis, the pisiforme was a rather large bone.

Measurements of Ulnæ (in millimeters)

	No. 4335, C. A. S. Left, *Allodesmus kernensis*	No. 21331, U. S. N. M. Left, *Odobenus divergens*	No. 7140, U. S. N. M. Left, *Eumetopias jubata*
Greatest length	365.0*	360.0	373.0
Greatest vertical diameter of greater sigmoid cavity	59.7	77.3	59.5
Greatest transverse diameter of greater sigmoid cavity	44.0	62.0	71.0
Greatest antero-posterior diameter of olecranon process	90.+	113.6	124.5
Greatest antero-posterior diameter of distal extremity of shaft	53.2	51.0	45.0
Greatest antero-posterior diameter of shaft at level of distal margin of greater sigmoid cavity	96.5	77.5	81.0

* Distal epiphysis missing.

Carpus

As in living pinnipeds, the carpus of *Allodesmus kernensis* is more broadened and flattened than in terrestrial carnivores. The scaphoid, lunar, and probably the centrale have fused to form one transversely elongated bone. The ulnar side of the carpus is shortened as in living otariids and the unciform is rather small. The magnum resembles the same bone in the carpus of *Eumetopias jubata* and a similar resemblance exists between the trapezium and unciform bones of these two pinnipeds. The other carpal bones are as yet unknown. The fifth metacarpal articulates with the ulnare and the external face of the unciform. This metacarpal is much shorter than any of the others.

Scapho-Lunar

Three right scapho-lunar bones are included in this collection, two (No. 4332, C. A. S., and No. 11859, U. S. N. M.) of which belong to very large individuals and one (No.

Right scapho-lunar of (?) *Allodesmus kernensis*, No. 4332, C. A. S., × 0.5. Fig. 31. Anterior view. Fig. 32. Distal view.

4369, C. A. S.) to a somewhat smaller individual, as is shown by the measurements. The two large carpals are somewhat eroded, but the smaller scapho-lunar with the exception of the radial border is well preserved. The writer is not quite certain that these large scapho-lunar bones belong to this pinniped, for the curvature of the radial articular surface is quite different from that of the smaller carpal. The internal half of the radial articular surface (fig. 33), although shallowly concave, is somewhat shorter than on the larger scapho-lunar bones, and the external half (fig. 34) has a broad flat depressed border in contrast to the rounded surface of the larger bones. The smaller scapho-lunar is characterized by the convexo-concave curvature of the radial articular surface, the narrow articular surface for the trapezium and trapezoid, and the presence of a prominent plantar tuberosity (fig. 35) internal to the facet for the unciform. The radial articular surface of the larger scapho-lunar bones have a more regular convex curvature, a

Right scapho-lunar of *Allodesmus kernensis*, No. 4369, C. A. S., × 0.5. Fig. 33. Anterior view. Fig. 34. Posterior view. Fig. 35. Distal view.

broader articular surface for the trapezium and trapezoid (fig. 32), and may lack the plantar articular tuberosity internal to the facet for unciform, but this surface is eroded on both carpals.

In general form these carpals are similar to the scapho-lunar of *Eumetopias jubata,* but the radial articular surface is much larger. The facets on the proximal and distal faces of this bone show that it was the largest of the carpal bones. The large convex articular facet which supports the radius covers most of the proximal surface. As compared with the same facet on the scapho-lunar of *Eumetopias,* this articular surface is fully one-third wider. Viewed from above, the ulnar border of this fossil scapho-lunar corresponds with the carpal of *Eumetopias,* but the radial border is conspicuously shorter. There are facets on the distal surface (fig. 32) for four of the carpal bones. An oblique crest crossing the distal surface from the antero-ulnar angle to the postero-radial angle separates the facet for the magnum from that for the trapezoid. On the scapho-lunar of *Eumetopias* there is one large continuous articular surface, concave from side to side, which rests upon the trapezium and the trapezoid. This fossil carpal has a similar articular surface, but the facet for the trapezium is depressed posteriorly. The facet for the magnum is relatively smaller than in *Eumetopias* and terminates on a prominent plantar tuberosity; the facet on the ulnar border for the unciform is less concave.

Measurements of Scapho-Lunars (in millimeters)

	No. 4369, C. A. S. Right, *Allodesmus kernensis*	No. 4332, C. A. S. Right, *Allodesmus kernensis*	No. 11859, U.S.N.M. Right, *Allodesmus kernensis*	No. 21537, U.S.N.M. Right, *Eumetopias jubata*
Greatest transverse diameter	60.+	78.0	76.+	81.0
Greatest proximo-distal diameter	43.3	49.0	48.	44.5
Greatest transverse diameter of combined facets for trapezium and trapezoid	50.+	66.0	62.+	51.2
Greatest transverse diameter of radial facet	49.0	60.8	56.5	44.5

Trapezium

Aside from its smaller size, the left trapezium (No. 4331, C. A. S.) referred to this pinniped bears a rather close resemblance to the corresponding carpal of a larger individual described in a previous paper.[14] Comparison with the trapezium of *Eumetopias jubata* shows that this carpal is relatively narrower in a dorso-plantar direction, the tuberosity on the radial face is placed much higher, the facets for the navicular and trapezium have a different declination, and the direction of the radial tuberosity causes the plantar face to appear concave.

The large radial tuberosity is furnished with an elliptical articular surface, presumably for a sesamoid. The facet for the trapezoid is double, the main facet extending from the proximal to the distal margin, and adjoining it on the distal border is the lesser facet whose shape is more or less hemicircular. The trapezium has a large concave facet on the distal face for the second metatarsal. The facet for the scapho-lunar curves downward toward the radial face as in *Eumetopias,* but the slope is less abrupt. The dorsal surface is flattened and somewhat roughened.

Measurements of Trapezia (in millimeters)

	No. 4331, C. A. S. Left, *Allodesmus kernensis*	No. 21537, U. S. N. M. Left, *Eumetopias jubata*
Greatest proximo-distal diameter	28.4	32.4
Greatest transverse diameter	34.7	33.4
Greatest dorso-plantar diameter	25.1	31.6
Greatest proximo-distal diameter of radial tuberosity	20.5	14.3

Magnum

The right magnum (No. 11860, U. S. N. M.) of a large individual differs from the corresponding tarsal of a large old

[14] R. Kellogg, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 13, no. 4, 1922, pp. 36-37, text figs. 11a-11b.

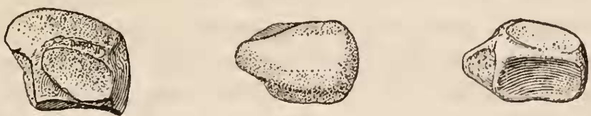
36 37 38

Right magnum of *Allodesmus kernensis,* No. 11860, U. S. N. M., × 0.5. Fig. 36. Proximal view. Fig. 37. Distal view. Fig. 38. Internal view.

male *Eumetopias jubata* chiefly in the curvature of the facets for articulation with the trapezoid, scapho-lunar, and unciform. The convex facet for the scapho-lunar is very narrow anteriorly, almost crest-like, and is broadest posteriorly. On the internal face is a concave facet for the trapezoid and on the external face is a much longer facet for the unciform, which follows the superior and anterior borders of the bone. The distal facet for the third metacarpal is quadrangular in outline and strongly concave in a dorso-plantar direction. The posterior face of this bone is much narrower than that of the living sea lion.

Measurements of the Magnum

Greatest dorso-plantar diameter	45.5 mm.
Greatest transverse diameter	22.8 mm.
Greatest proximo-distal diameter	31.5 mm.



39 40 41

Right unciform of *Allodesmus kernensis,* No. 11862, U. S. N. M., × 0.5. Fig. 39. External view. Fig. 40. Proximal view. Fig. 41. Distal view.

Unciform

The right unciform (No. 11862, U. S. N. M.) of a somewhat smaller individual has the same general conformation as the corresponding carpal of *Eumetopias,* but the internal face is relatively higher. It has large proximal facets for the

scapho-lunar and ulnare, a narrow facet for the magnum which follows the upper and anterior borders, and a large external facet for the fifth metacarpal. The facet for articulation with the scapho-lunar is flattened and elongated, while that for the ulnare is noticeably convex. The distal facet for the fourth metacarpal is strongly concave.

Measurements of the Unciform

Greatest dorso-plantar diameter	34.0 mm.
Greatest transverse diameter	24.5 mm.
Greatest proximo-distal diameter	26.8 mm.

Metacarpals

Several large metacarpals and phalanges are assumed to belong to an old male. They are structurally the same as those of smaller individuals which are described herewith:

The fifth left metacarpal (No. 4480, C. A. S.) lacks the distal extremity and seems to be deformed or pathological. The posterior surface of the shaft and head resemble those of diseased bones of the living sea lion. As with smaller individuals the facet for articulation with the ulnare is horizontal and that for the unciform is oblique.

The right (No. 4481, C. A. S.) and left No. 4478, C. A. S.) second metacarpal bones agree with those of smaller individuals in their general features, but are much larger and heavier bones. The proximal surface for articulation with the trapezoid curves from the plantar to the dorsal margin, and slopes from the external to the internal face. There is a large antero-proximal facet for articulation with the head of the third metacarpal.

Two very large metapodials (Nos. 4476, 4477, C. A. S.) are referred to this species. They belong to opposite limbs and may be from one individual. They are much shorter and heavier than the first metacarpals of any living otariid and may possibly belong in the first row of phalanges. The proximal ends are eroded to such an extent that the character of the facets can not be satisfactorily determined. The facet on the distal extremity is strongly convex. The shafts of these bones are flattened in a dorso-plantar direction and expanded laterally. Two smaller bones (Nos. 4479, 4483, C. A. S.), which

appear to be phalanges, are referred to this pinniped. One of these is similar in appearance to the larger bones described above.

A number of smaller metacarpals and phalanges are also referred to *Allodesmus kernensis.* One of them (No. 4482, C. A. S.) seems to be the terminal phalanx of the first digit of the manus.

As compared with those of *Eumetopias jubata,* the phalanges of the fore and hind limbs of this fossil pinniped are not only much wider, but the shafts are remarkedly flattened. The eight phalanges referred to this pinniped are shorter than corresponding bones of *Eumetopias,* but the articular surfaces on the proximal and distal ends of the shafts present the same structural peculiarities.

The following metapodials belong to somewhat smaller individuals. Both of the fifth right metacarpals bones referred to this pinniped are somewhat eroded. They are about the same size as those of *Eumetopias jubata.* The length and the transverse diameter of the shafts are approximately the same, but the shaft of the fossil metacarpal would appear triangular in cross section. The facets for articulation with the ulnare and unciform form one continuous oblique surface on the fifth metacarpal of *Eumetopias.* On the fossil metacarpal, the facet for the ulnare is horizontal and that for the unciform is oblique. The articular surface on the distal end of the shaft is broad and rounded, but has a deep concavity on the interno-plantar angle.

The fourth right metarcarpal bone (No. 4458, C. A. S.) can be articulated with the fifth metacarpals described above. It is slightly larger than the corresponding metacarpal of *Eumetopias jubata.* The head is large and rounded, with an oblique anterior facet for the magnum and a strongly convex proximal facet for the unciform. The plantar extension of the head is narrowed and directed inward as in *Eumetopias,* and the proportions of the shaft are likewise similar.

The third metacarpal bones hereinafter discussed may possibly represent two species of fossil pinnipeds and belong at least to individuals which differ considerably in size. These bones range in length from 72.8 mm. to 93.0 mm. In so far as the proportions of the shafts and the shape and extent of

Measurements of Metacarpals (in millimeters)

	I C. A. S. No.4465	I C. A. S. No.4466	III C. A. S. No.4459	III C. A. S. No. 4460	III C. A. S. No. 4461
Greatest length	......	......	73.5	72.8	80.0
Dorso-plantar diameter of head	28.+	41.0	25.8	21.4	27.4
Transverse diameter of head	32.5	40.0	23.4	20.0	24.4
Narrowest transverse diameter of shaft	......	......	15.2	13.3	13.3
Transverse diameter of distal end	......	......	22.4	19.2	23.5

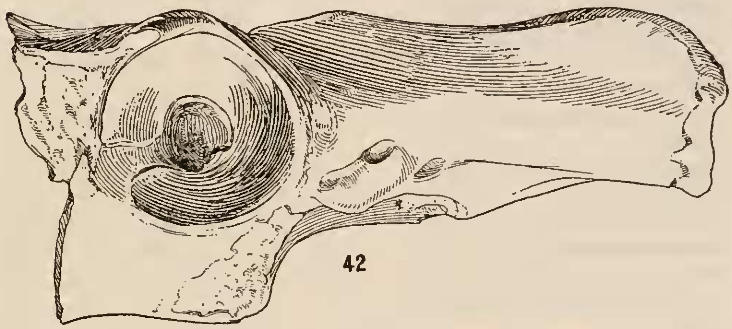
	III C. A. S. No.4462	III C. A. S. No.4463	IV C. A. S. No.4458	V C. A. S. No. 4451	V C. A. S. No. 4467
Greatest length	......	92.8	72.8	63.5	59.8
Dorso-plantar diameter of head	26.6	27.0	26.7	24.8	22.5+
Transverse diameter of head	22.5	26.0	25.3	27.5+	26.+
Narrowest transverse diameter of shaft	13.2	14.5	16.8	19.5	17.0
Transverse diameter of distal end	......	27.5	......	25.8	23.+

the articular facets are concerned, they agree rather closely with one another. The two larger bones (Nos. 4462 and 4463, C. A. S.) from the left and right manus, respectively, differ from the three smaller metacarpals in having the convex facet for the fourth metacarpal continuous with the proximal articular surface for the magnum. On the three smaller metacarpals (Nos. 4459, 4460, 4461, C. A. S.) this facet is subvertical in position and slightly concave. The oblique flattened facet for the head of the second metacarpal is similar to that of *Eumetopias*. The plantar extension of the head is somewhat narrower than in *Eumetopias* and the distal end of the shaft has a more rounded articular surface for the corresponding phalanx. The second metacarpal is not represented in this lot of bones. The right (16756, U. C.) and left (23170, U. C.) second metacarpal bones, which were described in a previous paper,[15] belong to an animal of approxi-

[15] R. Kellogg, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 13, no. 4, 1922, pp. 37-39, figs. 12a-c.

mately the same size as that to which the larger pair of third metacarpals (Nos. 4462, 4463, C. A. S.) belongs. One of these metarcarpals was erroneously described as the fourth metacarpal.

The proximal ends of two first metacarpals from the left manus show that this bone was similar to the corresponding bone of *Eumetopias jubata.* The facet for articulation with the trapezium crosses the head obliquely and the shaft is somewhat deeper than in *Eumetopias.*



42

Fig. 42. Right innominate bone of *Allodesmus kernensis,* No. 4360, C. A. S., × 0.5.

Pelvis

A portion of the right innominate bone (No. 4360, C. A. S.) of a large individual is included in this collection. The posterior half of this bone is missing (fig. 42). As compared with the corresponding bone of *Eumetopias jubata,* the anterior portion or ilium is not so deep and it is less expanded at the extremity, but the depth through the acetabulum is much greater. The greatest diameter of this fossil innominate bone through the acetabulum is 84.7 mm. as contrasted with a corresponding measurement of 77.0 mm. for an adult male *Eumetopias.* The least dorso-ventral diameter of the ilium is 45.3 mm. as compared to 55.0 mm. in the case of *Eumetopias.* The socket for the head of the femur is deep. The ilium curves outward as in *Eumetopias* and there are two deep irregular depressions on the internal face for the corresponding sacral vertebræ.

Measurements of Pelves (in millimeters)

	No. 4360 C. A. S. *Allodesmus kernensis* Temblor formation	No. 7140, U. S. N. M. *Eumetopias jubata*, Ad. ♂ St. Paul Island, Alaska	No. 7140, U. S. N. M. *Eumetopias jubata*, Ad. ♂, St. Paul Island, Alaska	No. 21537, U. S. N. M. *Eumetopias jubata*, Farallones Islands, west of San Francisco, Calif.
	Right	Left	Right	Right
Greatest length	....	249.0	247.0	255.0
Anterior margin of acetabulum to anterior margin of ilium	115.5+	129.5	130.0	105.4
Posterior margin of acetabulum to posterior margin of ischium	....	178.0	177.0	120.2
Antero-posterior diameter of thyroid foramen	....	127.5	123.2	67.0
Symphysis of pubis to tuberosity of ischium	....	115.0	114.7	117.0
Greatest diameter of innominate bone through acetabulum	84.7	77.5	77.0	71.7
Least dorso-ventral diameter of ilium	45.3	54.5	55.0	51.3

Femur

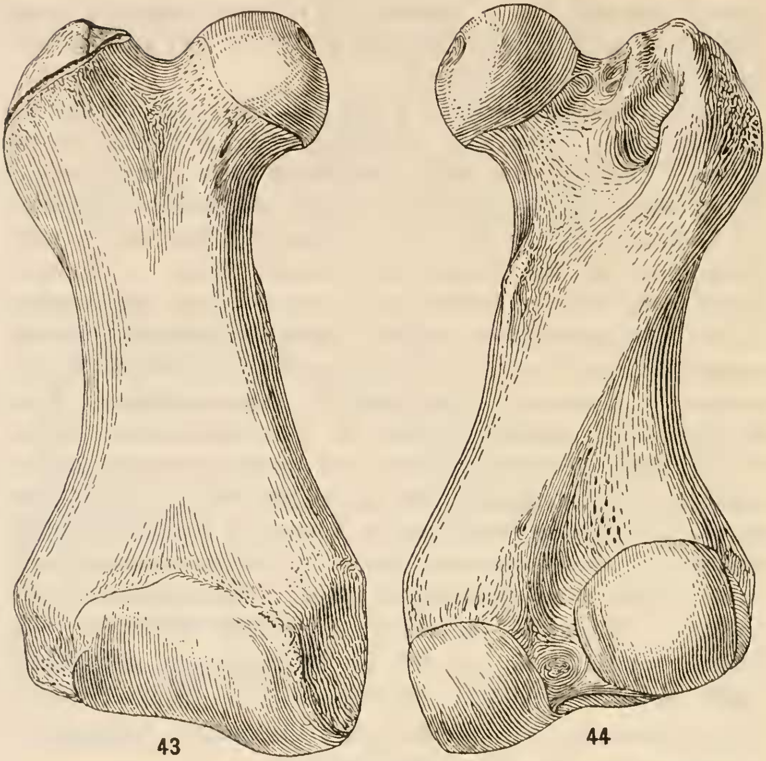
Among the various bones allocated to this fossil pinniped are femora of very large individuals, others from animals of medium size, and those which obviously belong to young. The four which belonged to animals of moderate size consist of the proximal end of a right femur (No. 4299, C. A. S.), the distal extremity of a slightly larger right femur (No. 4298, C. A. S.), and the eroded distal extremities of a left (No. 4301, C. A. S.) and a right femur (No. 4396, C. A. S.) of approximately the same size as the first mentioned fragment. The proportions of the proximal end of the shaft of the right femur indicate that this bone was more slender than the same bone of a larger individual (figs. 43-44). There are also other differences and of these the following appear to be the most important: (1) intercondyloid fossa almost as wide as the internal condyle; (2) a broad trochanteric crest which is not

limited internally by a tubercle; (3) a low crest-like lesser trochanter, with a depression above it; and (4) patellar surface limited to distal epiphysis.

Two of the three femora, which are represented by the distal extremities, have the epiphyses firmly ankylosed to the shafts. The proximal end of the right femur lacks the epiphysis which caps the shaft in the area of the greater trochanter. As in *Eumetopias jubata,* the overhang of the head is most pronounced on the anterior and internal faces. A little in front of the summit of the head is a large pit for the insertion of the *ligamentum teres* which is quite remarkable when one stops to consider that both the ligament and the depression are wanting on femora of living otariids. The trochanteric fossa is quite deep, measuring about 20 mm. across, and is continuous internally with the posterior surface of the neck. No counterpart of the depression above the low crest-like lesser tuberosity could be found on the femora of any of the living members of the family Otariidæ. The intertrochanteric crest is as distinct as in *Eumetopias jubata.* Below this crest the posterior surface of the shaft is distinctly flattened. The greater trochanter is broadest at the upper end and is distinctly narrowed distally. The depression on the anterior face of the femur between the head and the greater trochanter is smooth and not pitted as in *Eumetopias.*

At the distal end of the shaft, the external condyle is much larger than the internal, while in *Eumetopias* they are more nearly equal in size. The most peculiar feature of the distal ends of these femora, however, is the relatively great width of the intercondyloid fossa. The fossa for the posterior cruciate ligament is broad and that for the anterior ligament extends upward across the distal end of the shaft. The epicondyles are similar to those of *Eumetopias,* but the convex patellar surface is depressed mesially. The anterior face of the shaft above the patellar surface is not depressed as in the living otariids.

When compared with those of living pinnipeds, it is at once apparent that the only feature of especial interest possessed by these femora is the presence of a pit for the *ligamentum teres.* It is evident that these two large femora are intermediate in



Right femur of *Allodesmus kernensis*, No. 4294, C. A. S., × 0.5. Fig. 43. Anterior view. Fig. 44. Posterior view.

size between those of a very old male sea lion *(Eumetopias jubata)* and a female of the same species.

Briefly stated, these large femora (figs. 43, 44) are characterized by the following combination of characters: (1) presence of a large pit on the summit of the head for the insertion of the *ligamentum teres;* (2) presence of a large, deep trochanteric fossa on the inside of which is a well developed crest or tubercle presumably for the *gemellus superior;* (3) absence of any indication of an intertrochanteric crest; (4) rudimentary condition of the lesser trochanter; (5) a narrow and deep intercondyloid fossa; (6) external condyle considerably larger than the internal condyle; (7) a large area for the attachment of the anterior cruciate ligament, com-

parable in proportions to that of an old male *Eumetopias;* (8) patellar surface smooth, not depressed, and its superior border overspreads the distal end of the shaft; and (9) overhang of head about as in *Eumetopias.*

In respect to the separation of the epiphyses from the shafts the approach is directly toward the conditions existing in the bones of an immature animal, but this condition occasionally exists in old individuals of *Eumetopias.* Both of the femora of this large animal were found with the distal epiphyses separated from the shafts. The proximal epiphyses were attached to the shafts, but the line of demarcation is very distinct. In case of living sea lions and walruses, old individuals usually have the epiphyses ankylosed to the shafts and the line of contact is often obliterated. It is true that the bones of two smaller individuals, which were associated with those of this animal, have the epiphyses fused to the shafts.

Curiously enough, the shafts of both of these femora were fractured diagonally on a line running from the distal angle of the greater trochanter to a point above the internal epicondyle. The right femur, which is the more nearly complete of the two, is remarkable for its relative width as compared to that of an old male of the living sea lion *(Eumetopias jubata).* The head conforms in shape to the usual subhemispherical articular surface which fits into the acetabulum, and is directed inward and slightly forward. A little below the summit is an oval pit for the attachment of the *ligamentum teres.* The head is supported by a short stout neck, and the overhang of the former is most pronounced on the anterior and internal faces.

Posteriorly, where the neck unites with the shaft, there is a distinct intertrochanteric crest connecting the greater trochanter with the rudimentary lesser trochanter. No tubercle is developed for the *quadratus femoris,* and the insertion of this muscle appears to have been extended upward upon the lower half of the posterior border of the greater trochanter. The greater trochanter is a large, thin, semicircular epiphysis which caps the proximal end of the shaft and projects above the head. This portion of the shaft is considerably larger than the head and is obliquely truncated externally. On the posterior surface of the shaft is a deep trochanteric fossa, and, adjoining the fossa on the inside, is a rather prominent

tubercle or ridge, presumably for the insertion of the gemellus superior.

The lesser trochanter is rudimentary and consists of a low, short elevation crossing the postero-internal margin of the shaft in an oblique direction, and its main axis coincides with the usual direction of the intertrochanteric crest. Both sexes of *Eumetopias jubata* have a well developed lesser trochanter.

Viewed from in front, the face of the shaft is characterized by the rather even side-to-side curvature and the absence of any pronounced depression above the patellar surface, thus differing in the last mentioned respect from those of *Eumetopias* and *Odobenus*. The shaft is narrowest at the level of the lesser trochanter and is most expanded at the distal end. For descriptive purposes the internal surface of the shaft may be divided into a proximal portion extending as far as the usual position of the intertrochanteric crest, a narrow mesial portion lying between the latter and the ill-defined *linea aspera,* and the distal portion which extends from the latter to the condyles. The mesial portion is shallowly depressed and above the intercondyloid fossa on the distal portion of the shaft there is a rather large rugose depression which serves for the attachment of the anterior cruciate ligament. No trace of arterial foramina such as are present in *Eumetopias* and *Odobenus* could be found on the postero-internal surface of the shaft.

Capping the distal end of the shaft is the epiphysis which presents the condyles and the patellar surface. The articular surfaces of the condyles are continuous in front with the large patellar surface and are separated mesially by the deep intercondyloid fossa. Viewed from their posterior aspect, the external condyle is seen to be the larger and the broader of the two. The side-to-side convexity of the external condyle is much more pronounced than is the case with the internal. The external epicondyle presents a rough, elevated surface, but the internal epicondyle is depressed. The margins of the patellar surface are worn and one can not determine to what extent they were raised above the surrounding bony epiphysis.

In addition to this pair of large femora there are also a smaller pair (Nos. 4296, 4297, C. A. S.) which obviously belong to a young animal. These bones have the epiphyses missing at both ends of the shaft. They measure 125 and 126

Measurements of Femora (in millimeters)

	No. 21331, U.S.N.M. Ad. Right, *Odobenus divergens*	No. 7140, U.S.N.M. Ad. Left, *Eumetopias jubata*	No. 4294, C. A. S. Ad. Right, *Allodesmus kernensis*	No. 4295, C. A. S. Ad. Left, *Allodesmus kernensis*	No. 7156, U.S.N.M. Yg. Left, *Odobenus divergens*	No. 4296, C. A. S. Yg. Right, *Allodesmus kernensis*	No. 4297, C. A. S. Yg. Left, *Allodesmus kernensis*	No. 4298, C. A. S. Ad. Right, *Allodesmus kernensis*	No. 4299, C. A. S. Ad. Right, *Allodesmus kernensis*	No. 4300, C. A. S. Ad. Right, *Allodesmus kernensis*	No. 11537, U.S.N.M. Ad. Right, *Eumetopias jubata*	No. 16750, U. C. Yg. Left, *Allodesmus kernensis*	No. 16755, U. C. Yg. Right, *Allodesmus kernensis*
Greatest length (head to internal trochlea)	244.8	220.0	198.3	197.5[1]	146.4[2]	125.0[2]	126.0	......	......	140.4	167.4	132.2	......
Greatest transverse diameter of proximal end (head to greater trochanter).....	114.0	91.7	94.3	95.0	......	......	......	......	80.0	74+	67.8	......	......
Extero-internal diameter of shaft at narrowest point.....................	65.6	44.2	48.5	48.2	41.8	35.5	35.4	......	......	36.4	36.5	37.4	......
Greatest transverse diameter of distal end (internal to external epicondyla)..	113.0	88.7	95.0	......	......	......	......	88.0	......	......	71.8	......	78.0
Greatest diameter of head............	52.7	41.5	43.0	43.2	......	......	......	......	37.5	......	35.5	......	......
Greatest transverse diameter of external trochlea.........................	41.6	36.0	41.7	40.5	......	......	......	37.4	......	......	29.0	......	26.1
Greatest transverse diameter of internal condyle.........................	36.3	34.2	32.4	33.7	......	......	......	......	......	......	28.4	......	32.5
Breadth of intercondyloid fossa at narrowest point.....................	18.4	21.5	15.4	15.1	......	......	......	20.8	......	......	15.3	......	......
Breadth of distal end of shaft.........	......	88.5	......	86.0	73.8	76.8	73.3	......	......	53+	73.8	66.7	......
Breadth shaft at proximal end........	......	85.1	......	......	83.2	72.8	......	......	......	......	......	69.4	......

[1] Distal epiphysis missing.

[2] Both epiphyses missing.

mm. in length, respectively. Before taking up in detail a consideration of these smaller femora, it seems advisable to discuss their relationship to another femur[16] described from the same deposits in a previous paper. It is now apparent that the left femur associated with the type mandible of *Allodesmus kernensis* belongs to a young individual and that in all probability it does not belong to the same individual as the jaw. This femur, unlike the two hereinafter described, has a fairly distinct intertrochanteric crest. These smaller femora present all the salient features of the larger femora described above. Anteriorly the shaft is more or less flattened at the distal end and proximally the surface slopes to the outer border, giving the shaft a twisted appearance. Turning to the posterior face we find that there is no indication of an intertrochanteric crest and that the lesser trochanter is represented by a low elevation. The trochanteric fossa is well defined, but the internal crest, or tubercle, which is developed on the larger femora, is missing. The depression at the distal end of the anterior cruciate ligament is well defined. In comparison with those of the larger femora, the neck, which supports the head, appears to be proportionately thicker than the portion of the shaft which bears the greater trochanter.

Patella

The knee joint of this fossil pinniped was protected by a large patella. The base of this sesamoid bone is more or less quadrangular in outline and is furnished with a large, oval, concave, articular surface whose main axis is oblique to the proximo-distal axis of the patella itself. The distal angle of this bone is drawn out into a rounded peak, and the major portion of the anterior surface slopes to the proximal margin. Beginning near the middle of the external border and curving around the distal face is a broad groove for some ligament. A similar groove, with less sharply defined margins, is present on the internal border. Nine patellæ ranging in size from one with a proximo-distal diameter of 62.5 mm. to one measuring not more than 45 mm. were sorted out of this collection. At the distal end, the largest of these sesamoids has a depth of

[16] R. Kellogg, Univ. Calif. Publ. Geol. Sci., vol. 13, No. 4, 1922, pp. 39-40, text figs. 14a-14b.

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Fig. 45. Patella of *Allodesmus kernensis*, No. 11544, U. S. N. M., × 0.5.

41.2 mm. and the corresponding measurement for the smallest is 30.4 mm. Most of these sesamoids are more eroded than the one here figured (fig. 45).

Tibia

Comparison with the tibiæ of living otariids indicates that the tibia (No. 4304, C. A. S.) of young males or females of *Allodesmus kernensis* may be distinguished by the following combination of characters: (1) shaft irregularly three-sided, but without distinct anterior longitudinal crest; (2) proximal end of shaft not fused with head of fibula; (3) posterior surface of shaft distinctly flattened; (4) posterior intercondyloid fossa relatively small and anterior intercondyloid fossa almost obliterated; (5) intercondyloid eminence relatively low; and (6) a single groove for tendons of *tibialis posticus* and flexor muscles of the foot on internal border of posterior surface of distal end of shaft.

The left tibia (fig. 46) of this fossil pinniped has about the same proportions as the corresponding bone of the living sea lion *(Eumetopias jubata)*, but differs from the latter in that it was not united with its neighbor, the fibula, at the proximal end. This fossil tibia is, nevertheless, slightly shorter than that of an adult *Eumetopias jubata* (No. 21537, U. S. N. M.).

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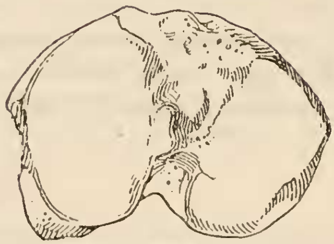

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Left tibia of *Alodesmus kernensis,* No. 4304, C. A. S., × 0.5. Fig. 46. External view. Fig. 47. Proximal view. Fig. 48. Distal view.

Inasmuch as the condyles of the femur articulate with the proximal expanded extremity of the tibia, condylar facets of corresponding proportions are developed on this surface (fig. 47), the external articular facet being somewhat larger than the internal. Both condylar facets are more or less flattened in comparison to those on the tibia of *Eumetopias jubata* and the intercondyloid eminence is not as prominent. The posterior intercondyloid fossa is much shallower and slightly narrower than in *Eumetopias*. Whereas, the anterior intercondyloid fossa is rather broad and deep on the tibia of the recent sea lion, it is almost obliterated on this fossil bone and is limited to a small pit whose area is even less than the rounded intercondyloid eminence. The external condyle overhangs the shaft to a greater extent than the internal, a modification correlated with the position of the fibula. The roughened surface for the head of the fibula is placed postero-externally on the distal surface of the overhang produced by the lateral expansion of the condylar facet. A shallow facet for the patella is present on the anterior face of the proximal end of the tibia, and this surface terminates on each side at the internal margin of the condylar facet.

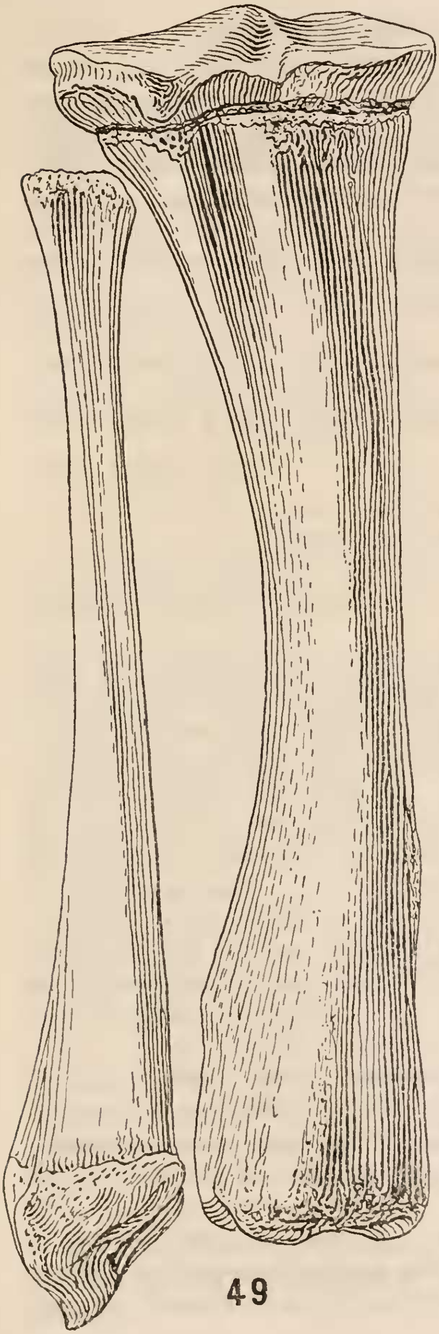
The shaft of the tibia is irregularly three-sided, possessing an anterior, an external, and a posterior surface. The expanded extremities of the shaft support the epiphyses which bear the articular facets. The longitudinal anterior crest, which defines the limits of the anterior and external surface, is not as distinct as in *Eumetopias jubata,* but the interosseous crest, which separates the external from the posterior surface, is as sharp-edged as in the living animal. The shaft itself is bowed forward and inward, and is narrowest near the middle. The posterior surface of the shaft is distinctly flattened in comparison to that of *Eumetopias,* there being only a slight indication of the longitudinal depression for the *tibialis posticus* on the proximal third, but there is no trace of an oblique crest such as extends across the distal half of the tibia of the sea lion. The interosseous crest terminates about 28 mm. above the distal epiphysis, and below this the shaft expands to provide an area for articulation with the distal end of the fibula. This fibular articulation facet is limited to the epiphysis of the tibia, and measures 26 mm. in width and 10 mm. in depth.

The posterior face of the distal extremity of the tibia of *Eumetopias jubata* displays two deep grooves, of which the mesial or tibial groove is the narrowest. The groove on the internal border is quite broad and is bordered by high crests. Over these grooves pass the tendons of the *tibialis posticus* and the flexor muscles of the foot. On this fossil tibia there is a single broad groove, bordered by low crests, which is placed on the internal border of the posterior face of the distal epiphysis.

The distal end of the fossil tibia (fig. 48) is furnished with a saddle-like articular surface, which rests upon the trochlea of the astragalus. This articular surface is similar in contour to that on the tibia of *Eumetopias,* but the antero-posterior convexity is less pronounced. In front of and internal to this articular surface is the usual knob-like malleolus. There are, in addition to this specimen, the proximal end of a left tibia (No. 4492, C. A. S.), without the epiphysis, of a somewhat smaller individual, and the epiphysis of a right tibia (No. 4493, C. A. S.) from an individual about the same size as the one whose tibia is described above.

Some idea of the size of a large individual of this fossil pinniped is afforded by the proportions of this tibia (No. 4303, C. A. S.). By referring to the measurements given below, it will be seen that this tibia is considerably shorter than that of an old male sea lion *(Eumetopias jubata)* or of a walrus *(Odobenus divergens)*. The shaft of the tibia of the walrus forms a sinuate curve, but that of the sea lion is bowed forward. This fossil tibia (fig. 49), however, has: (1) a shaft with a nearly straight anterior profile; (2) a very limited development of the proximal depression for the *popliteus;* (3) a single groove for tendons of the *tibialis posticus* and flexor muscles of the foot; (4) a narrow posterior intercondyloid fossa; and (5) a pit-like anterior intercondyloid fossa.

The shafts of the right (No. 4302, C. A. S.) and left (No. 4303, C. A. S.) tibia are fractured transversely in two or more places, but are otherwise in a fair state of preservation. The epiphyses of these bones are not attached to the shafts. A proximal epiphysis for the tibia was included in the collection, but the remaining epiphyses were not found. The distal epi-



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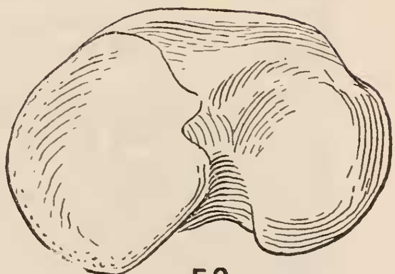

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Left tibia and fibula of *Allodesmus kernensis,* Nos. 4303, 4305, C. A. S., × 0.5. Fig. 49. Internal view. Fig. 50. Proximal view.

Measurements of Tibiæ (in millimeters)

	No. 4304, C. A. S. Left, *Allodesmus kernensis*	No. 4302, C. A. S. Right, *Allodesmus kernensis*	No. 4303, C. A. S. Left, *Allodesmus kernensis*	No. 7140, U.S.N.M. Left, *Eumetopias jubata*	No. 21331, U.S.N.M. Left, *Odobenus divergens*
Greatest length of tibia....	280.6	281.0[1]	296.5[2]	357.0	374.0
Greatest diameter of shaft at distal end..............	58.6	62.0	61.0	63.0	71.0
Greatest diameter of shaft at proximal end............	66.0	73.8	75.0	78.0	98.0
Transverse diameter of shaft at narrowest point.......	35.2	33.0	33.5	29.5	37.8
Greatest diameter of proximal epiphysis............	78.8	....	91.0	98.5	103.7

[1] Both epiphyses missing. [2] Distal epiphysis missing.

physis (No. 4494, C. A. S.) of another large individual was secured.

The proximal epiphysis of this fossil pinniped is very similar to that of the smaller individual (No. 4304, C. A. S.). The articular surface of this proximal epiphysis (fig. 50) is furnished with a large external condylar facet and a considerably smaller internal one. The external condylar facet is slightly convex and the internal is shallowly concave, and the whole proximal surface is distinctly flattened, paralleling in this respect the head of the walrus tibia. The intercondyloid eminence is low, but the posterior intercondyloid fossa is reduced to a narrow re-entrant angle and the anterior intercondyloid fossa is restricted to a small pit-like depression. In position and extent, the facet for the patella is similar to that of the smaller individual (No. 4304, C. A. S.).

There is a pronounced overhang to the external condyle, notwithstanding the loss of a portion of the external border. On the proximal end of the shaft and below the overhanging external condyle is a roughened surface for the head of the fibula.

When viewed from the side, attention is at once directed to the expansion of the extremities and to the mesial constriction of the shaft. The anterior profile of the shaft is nearly straight

and the external is strongly curved. While the shaft is roughly three-sided, the surfaces pass into one another so gradually that the anterior longitudinal crest is not developed and the external interosseous crest is visible only at the distal end. The tibia of the walrus is furnished with a well defined longitudinal depression on the proximal half of the posterior face of the shaft for the attachment of the *popliteus*. These fossil tibiæ, however, are not similarly modified for this muscle. Two short crests below the posterior intercondyloid fossa indicate the position of this muscle.

A single groove is present on the internal border of the posterior surface of the distal end of the shaft for the tendons of the *tibialis posticus* and the flexor muscles of the foot.

Fibula

Unfortunately, the head of the left fibula (fig. 49) is lost and the distal epiphysis is separated from the shaft. In the details of shape and of form the fibula of this fossil pinniped presents some variations from the usual otariid type. The shaft is slender and the extremities, especially the distal one, are enlarged. It has three lateral surfaces, the anterior, the posterior, and the internal or medial. The anterior surface of the shaft of the fibula increases in width from the proximal to the distal end. This surface is distinctly flattened and in this respect it is more like the fibula of *Eumetopias* than that of *Odobenus*.

There is no trace of an interosseous crest. This fossil fibula does agree with those of *Eumetopias* and *Odobenus,* however, in that the external border of the distal end of the shaft is furnished with a short crest, not more than 27 mm. in length. The posterior surface is convex and is continuous with the medial or internal surface except on the proximal fourth where they are separated by a sharp-edged, longitudinal crest. The proximal half of the shaft of the fibula of *Odobenus* is distinctly flattened in a postero-internal direction, and in *Eumetopias* this flattening of the shaft is even more pronounced, but is limited to the proximal fifth. The corresponding portion of the shaft of this fossil fibula would appear triangular in cross section.

The distal epiphysis is roughly pyramidal in form and is furnished with articular surfaces for the astragalus and the tibia. The articular surface for the lateral side of the astragalus resembles that of the walrus, and its general shape is quite unlike the corresponding facet on the fibula of the sea lion. This facet is constricted mesially, and may be described as consisting of a basal articular surface, which extends the full length of the tibial border, and a distal spatulate articular surface with crest-like margins.

There is one feature, however, which is quite remarkable and that is the presence of a broad groove bordered by high crests on the posterior face of the distal epiphysis. There is an indistinct groove for a similar tendon on the fibula of *Eumetopias*, but it seems to be undeveloped on the fibula of *Odobenus*. The facet for articulation with the tibia resembles that on the fibula of the walrus.

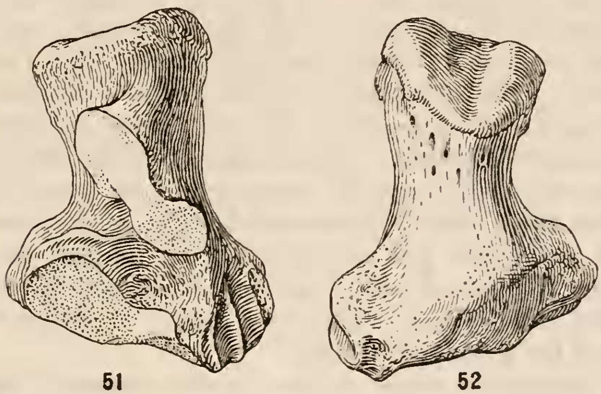
Measurements of Fibulæ (in millimeters)

	No. 4305, C. A. S. Left, *Allodesmus kernensis*	No. 21537, U. S. N. M. Left, *Eumetopias jubata*	No. 21331, U. S. N. M. Left, *Odobenus divergens*
Greatest length of fibula	280.5	252.4	367.0
Greatest diameter of shaft at proximal end	30.0	37.4	41.0
Greatest diameter of shaft at distal end	43.8	30.7	54.2
Least postero-internal diameter of shaft	15.8	6.7	14.0

Tarsus

The tarsus of this fossil pinniped is quite similar in many respects to that of the living *Eumetopias jubata*. There are, of course, important modifications in the individual tarsal bones. The calcaneum, for instance, is characterized by its thicker shaft and more expanded distal extremity, by the curvature and outlines of the sustentacular facet, and by the presence of a broad longitudinal groove on the internal face of

the greater process. The astragalus has a short neck and the postero-superior portion of the body is raised above the trochlea. It has in addition a distinct facet for the cuboid and a deep pit for the attachment of a tendon on the anterior border of the articular surface for the navicular. The navicular does not have a facet for a sesamoid and the facet for the cuboid is rather narrow. The cuboid is characterized in part by the shallowness of the groove for the peroneal tendon. The entocuneiform, however, resembles that of *Odobenus* in having the proximal facet for the mesocuneiform extended across the fibular face. The other tarsal bones are unknown.



Left calcaneum of *Allodesmus kernensis,* No. 4309, C. A. S., × 0.5. Fig. 51. Plantar or posterior view. Fig. 52. Dorsal or anterior view.

Calcaneum

A very strong reason for considering that both sexes are represented among these eight calcaneal bones is the corresponding disparity in size between the bones of male and female otariids. The five calcaneal bones (Nos. 4309, 4310, 4312, 4313, 4315, C. A. S.) referred to males of this species may be conveniently grouped according to size, the larger pair probably belonging to an old male and the smaller ones to young males. Size alone distinguishes the two larger calcaneal bones (Nos. 4309, 4310, C. A. S.) from the three smaller ones. All of these tarsals are quite robust and the two

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larger ones are exceptionally well preserved. The three smaller calcaneal bones (Nos. 4312, 4313, and 4315, C. A. S.) are eroded and broken. The two larger calcaneal bones may have belonged to the same individual, inasmuch as they agree in size and appearance. The left calcaneum (No. 4309, C. A. S.) is the best preserved, and the following description is based largely upon this bone.

Aside from its thicker shaft and more expanded distal extremity, the calcaneum (fig. 51) of this fossil pinniped bears a close resemblance to the corresponding tarsal of an old male *Eumetopias jubata*. As compared with the calcaneum of *Odobenus divergens*, this fossil tarsal is distinguished by the great side-to-side expansion of the distal extremity and by the twisting of the shaft toward the inside of the foot. The distal extremity of the calcaneum of *Odobenus* is not disproportionate to the size of the head and the shaft is not noticeably constricted near the middle. The calcaneum of *Eumetopias*, however, has the distal extremity expanded in the same direction as in this fossil tarsal. On the plantar face of this fossil calcaneum and in the area corresponding to the heel, the distal extremity is provided with a smooth surface, and its proximal extremity is furnished with a broad groove for the accommodation of the tendon of Achilles.

The anterior or dorsal surface of the calcaneum (fig. 52) is furnished with two large facets for articulation with the astragalus. Crossing the calcaneum near the middle is the greater facet on which the ectal facet of the astragalus articulates. This facet is constricted mesially and has raised margins. Below this facet is the rugose sinuate groove for the interosseous ligament. To the inside of this groove is an elongated facet which extends across the internal half of the distal border of the calcaneum and is deeply concave in the direction of its long axis. Upon this articular surface rests the sustentacular facet of the astragalus. This facet differs in shape and direction from the corresponding facet on the calcaneum of *Eumetopias* and *Odobenus*. In case of *Eumetopias*, this facet does not extend laterally to inner margin of the greater process but it does in case of *Odobenus*. No vestige of the broad longitudinal groove which traverses the internal face of the greater process of this fossil calcaneum was found

Measurements of Calcanea (in millimeters)

	No. 7140, U.S.N.M. Ad. ♂, *Eumetopias jubata*	No. 4309, C. A. S. ♂—Left, *Allodesmus kernensis*	No. 4310, C. A. S. ♂—Right, *Allodesmus kernensis*	No. 4312, C. A. S. Right, *Allodesmus kernensis*	No. 4313, C. A. S. Left, *Allodesmus kernensis*	No. 21537, U.S.N.M. Left, *Eumetopias jubata*	No. 11589, U.S.N.M. Right, *Allodesmus kernensis*	No. 11540, U.S.N.M. Right, *Allodesmus kernensis*	No. 4314, C. A. S. Right, *Allodesmus kernensis*
Greatest antero-posterior diameter of distal end	40.5	41.0	41.0	......	......	32.0	28.5	35.8	35.5
Greatest extero-internal diameter of distal end	62.5	72.8	......	......	......	51.5	50.4	58.8	52.+
Greatest proximo-distal diameter of ectal facet	43.8	49.6	49.5	43.5	......	32.3	34.5	38.5	35.2
Greatest extero-internal diameter of sustentacular facet	41.3	40.0	41.0	......	34.5	32.9	31.8	32.5	32.5
Greatest transverse diameter of head	45.8	48.7	48.3	......	41.0	37.2	31.5	35.5	......
Least transverse diameter of shaft	30.8	35.5	36.0	30.0	30.8	22.8	22.5	26.5	30.0
Greatest antero-posterior diameter of cuboid facet	40.0	27.0	26.0	......	......	27.7	21.0	22.5	......
Greatest length, proximo-distally	103.2	97.3	97.0	75.+	......	81.2	68.0	77.8	73.+

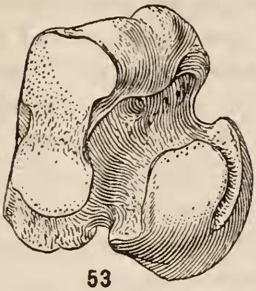
on the calcaneum of either *Eumetopias* or *Odobenus.* The peroneal tubercle on the other hand bears a close resemblance to that on the calcaneum of *Eumetopias.* The external border of the distal extremity is traversed by a rather broad groove, over which probably passed the ligament for the extensor muscles of the digits.

The distal surface of the calcaneum is furnished with a large facet for articulation with the cuboid. This facet is shallowly concave, with its transverse diameter approximately equal to its antero-posterior diameter. The anterior margin of the facet for the cuboid is co-extensive with the corresponding margin of the facet which articulates with the sustentacular facet of the astragalus, paralleling conditions in the calcaneum of *Eumetopias* and differing in this respect from the calcaneum of *Odobenus* on which these facets are united by a narrow isthmus.

The proper allocation of disassociated skeletal elements is often puzzling, and occasionally uncertain, in case of closely related animals. The three calcaneal bones (Nos. 11589 and 11540, U. S. N. M. and 4314, C. A. S.) referred to females are lighter and less robust than those assumed to belong to males of *Allodesmus kernensis,* but are otherwise quite similar. As compared with the calcaneum of larger individuals these tarsal bones are distinguished by having a more slender shaft, a narrower peroneal tubercle, and a less robust and more rounded greater process. The facets for articulation with other tarsal bones agree in all essential features with those on the calcaneum of larger individuals.

Astragalus

Inasmuch as the astragalus is the bone upon which the tibia and fibula rest, it transmits the weight of the body to the foot. The shape and relations of the astragalus with the tibia and fibula in turn indicate the extent to which the hind limbs may be used for progression on land. Corollary, and perhaps contributory, to the amount of rotation permissible, is the relative position of the fibular articular surface. The otariid type of astragalus permits the foot to be used for walking, while the phocid type of astragalus in conjunction with certain muscular



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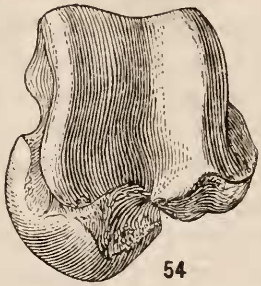

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Left astragalus of *Allodesmus kernensis,* No. 4308, C. A. S., × 0.5. Fig. 53. Dorsal or anterior view. Fig. 54. Plantar or posterior view.

relations restrict rotation and prevent the foot from being turned forward for progression on land.

In many of its essential features, the astragalus of this fossil pinniped agrees with the odobenid type and it is therefore not unlikely that this Miocene animal made use of its hind feet in progression on land. The neck is distinctly shorter than in *Eumetopias jubata*, and the extero-lateral process of the body is less twisted. The dorsal surface of the body of this fossil astragalus (fig. 53) is provided with a saddle-shaped trochlea, as wide in front as behind, for articulation with the distal end of the tibia. The lateral borders of the trochlea are rounded and the posterior margin of the latter terminates at the level of the anterior margin of the astragalar foramen. The postero-superior border of the body is raised above the trochlea. In case of *Odobenus divergens,* the astragalus is furnished with a rather large astragalar foramen, but, in *Eumetopias jubata,* the foramen is rather variable in its occurrence, and, when present, it is vestigial or incomplete. The astragalus of *Odobenus* differs from those of *Eumetopias* and this fossil pinniped in another feature, for it is furnished behind the outer half of the trochlea with a deep transverse groove for the *flexor digitorum,* which extends half way across the body and terminates on the posterior border of the external face about mid-way between the upper and lower margins of the lateral facet for the fibula. A very strong tendon would be required to produce a modification of this sort.

Over the external face of the body of the astragalus extends a large articular surface, which is convex above and concave below, for the distal end of the fibula. Distally, a crest-like margin defines the limits of this articular surface, and, anteriorly, it is continuous with the outer border of the trochlea. The distal or extero-lateral process of the body of the astragalus is somewhat everted. The internal face of the astragalus is excavated for the attachment of a ligament.

On the posterior or plantar surface of the body (fig. 53) is an elongated concave ectal facet, which rests upon a corresponding surface on the dorsal or anterior surface of the calcaneum. This articular surface resembles a boot in general outline, with the heel at the extero-superior angle of the body and the toe behind the astragalar foramen. In length and shape this ectal facet is more like that on the astragalus of *Odobenus* than on that of *Eumetopias*. Internal to this ectal articular facet and crossing the bone from the external border of the neck to the inferior opening of the astragalar foramen is a deep furrow for the attachment of the interosseous ligament. This furrow also extends upward between the external prolongation of the body and the head, ending in a depression on the lower border of the trochlea. This astragalus is thus attached to the calcaneum in the same manner as in the living Odobenidæ and Otariidæ. The smaller elliptical sustentacular facet has a slightly convex curvature and its disto-internal margin is separated from the navicular articular surface of the head by a much narrower groove than is present in either *Eumetopias* or *Odobenus*.

The astragali of *Odobenus* and of this fossil pinniped each have a broad furrow, continuous mesially with that for the interosseous ligament, which crosses the neck between the sustentacular facet and the medial or internal tubercle. On the astragalus of *Eumetopias*, however, the sustentacular facet is not separated from the medial or internal tubercle by a furrow. In proportion to the size of the body of the astragalus, the head is smaller than in *Odobenus*, but is not as noticeably flattened antero-posteriorly. Curiously enough the astragali of *Eumetopias* and of this fossil pinniped have a deep pit for the attachment of a tendon on the anterior border of the articular surface for the navicular and the resulting indentation of this

Measurements of Astragali (in millimeters)

	No. 11541, U.S.N.M. Left, *Allodesmus kernensis*	No. 4308, C. A. S. Left, *Allodesmus kernensis*	No. 4307, C. A. S. Left, *Allodesmus kernensis*	No. 23166, U. C. Left, *Allodesmus kernensis*	No. 4311, C. A. S. Left, *Allodesmus kernensis*	No. 4306, C. A. S. Right, *Allodesmus kernensis*	No. 21537, U.S.N.M. Left, *Eumetopias jubata*	No. 218322, U.S.N.M. Left, *Odobenus divergens*	No. 7140, U.S.N.M. Ad. ♂ *Eumetopias jubata*	No. 21537, U.S.N.M. *Eumetopias jubata*	No. 7141, U.S.N.M. *Eumetopias jubata*
Greatest vertical diameter	62.6	78.3	64.3	64.2	64.+	71.+	65.2	95.0	80.0	62.8	61.2
Greatest transverse diameter (head to fibular process)	54.0	66.0	56.+[1]	57.5	58.9	63.3	64.0	81.4	73.0	64.9	62.5
Greatest diameter of head	34.0	46.5	36.+	41.0	38.5[1]	42.3	42.6	63.0	51.5	42.7	39.6
Greatest diameter of ectal facet	42.0	50.4	40.8	38.+	......	45.0	33.5	58.0	42.7	32.5	30.5
Greatest dorso-plantar diameter of body	44.5	56.5	46.3	42.8+	......	44.9	36.5	62.7	43.7	36.5	33.8

[1]Head incomplete.

facet distinguishes these tarsal bones from the astragalus of *Odobenus.* The acquisition of additional astragali of this fossil pinniped shows that a previous interpretation of the facets on the head[17] was incorrect, and demonstrates that a distinct facet for the cuboid is present. The facet on the postero-internal surface of the head for articulation with the cuboid is large, sub-triangular in outline, and its surface is continuous with the sustentacular and navicular facets.

On the whole, the astragalus of this fossil pinniped seems to be characterized by having (1) the articular surfaces of head and trochlea not separated by a rugose interval; (2) an elongated boot-shaped ectal facet; (3) an astragalar foramen which is generally open; (4) a concave trochlea and a raised postero-superior border of the body; (5) a deep groove for the interosseous ligament; (6) the inferior border of sustentacular facet separated from the navicular facet by a narrow groove extending inward from the internal border; and (7) a large subtriangular facet on the head for articulation with the cuboid.

. The variation in size which exists in these six astragali is strictly comparable to that which distinguishes very old and immature individuals of the recent sea lion *(Eumetopias jubata).*

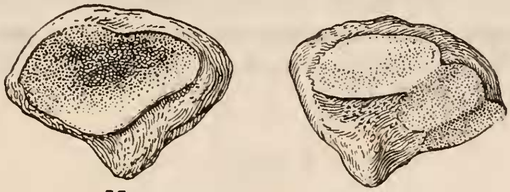
Navicular

These three fossil naviculars (No. 4321, C. A. S.; No. 11550, U. S. N. M.; No. 11551, U. S. N. M.) agree with the corresponding tarsals of *Eumetopias jubata* in their general proportions although they vary considerably in size, but they lack the facet for a sesamoid and the articular surface for the cuboid is reduced in extent. They are not only less massive than the navicular of *Odobenus divergens,* but differ from the latter in having a narrower facet for the cuboid and a greater dorso-plantar diameter. The dorso-plantar diameter is approximately three-fourths of the transverse tibio-fibular diameter.

The large oval articular facet (fig. 55) for the astragalus is strongly concave, with a pronounced upward curvature on the tibial and fibular borders. The dorsal surface is convex from side to side and is roughened for the attachment of a ligament.

[17] R. Kellogg, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 13, no. 4, 1922, p. 42.

The internal angle is rounded and does not appear to have articulated with a sesamoid. The navicular of *Eumetopias* has a large facet for a sesamoid on the internal face, but this facet is missing on the navicular of *Odobenus*. The external face is



55 56

Left navicular of *Allodesmus kernensis*, No. 4321, C. A. S., × 0.5. Fig. 55. Proximal view. Fig. 56. Distal view.

obliquely truncated and is furnished with a short, narrow, articular surface for the cuboid. Both *Eumetopias* and *Odobenus* have the navicular furnished with a well defined facet for articulation with the cuboid. On the plantar face and nearest to the tibial border is a prominent tuberosity or plantar process. The distal surface (fig. 56) is furnished with three facets for articulation with the cuneiform bones. In relative position, the facets for the cuneiforms are similar to those in *Eumetopias*. The largest of these facets rests upon the entocuneiform and extends half way across the bone. This

Measurements of Naviculars (in millimeters)

	No. 11550, U. S. N. M. Left, *Allodesmus kernensis*	No. 11551, U. S. N. M. Left, *Allodesmus kernensis*	No. 4321, C. A. S. Left, *Allodesmus kernensis*
Dorso-plantar diameter	33.8	35.4	45.4
Tibio-fibular diameter	47.1	53.5	60.2
Greatest vertical diameter	13.2	19.5	20.7
Greatest transverse diameter of facet for navicular	37.7	40.8	47.0
Greatest transverse diameter of facet for entocuneiform	28.4	32.4	36.0

articular surface is elliptical in outline and is very slightly convex. Adjacent to it on the fibular border is a somewhat broader concave facet for the mesocuneiform, and the latter in turn passes imperceptibly into the obliquely placed facet for the ectocuneiform. The facets for the cuneiforms do not cover most of the distal surface as in *Odobenus* and the posterior rugose area suggests that in so far as this tarsal is concerned the ligamentary structures were similar to those in the tarsus of *Eumetopias.*

Cuboid

Included among the tarsal bones referred to this animal are six cuboids of several sizes, the larger of which are referred to males and the smaller to females. Aside from size, the smaller and the larger cuboids differ in the relative development of the groove for the long peroneal tendon. The cuboid here figured is smaller than the one described in a previous paper,[18] but,

57 58 59

Left cuboid of *Allodesmus kernensis,* No. 4319, C. A. S., × 0.5. Fig. 57. Plantar view. Fig. 58. Tibial view. Fig. 59. Dorsal or anterior view.

like its mate, is somewhat larger than the four remaining cuboids.

There are two facets on the proximal end of the cuboid, the larger of which is strongly convex and supports the calcaneum. The smaller facet is concave and articulates with the astragalus and navicular. The pyriform facet, which articulates with the ectocuneiform, is placed between the distal margin of the superior facet and the proximal margin of the inferior facets

[18] R. Kellogg, Univ. Calif. Publ. Dept. Geol. Sci., vol. 13, no. 4, 1922, pp. 42-44, text figs. 17-19.

Measurements of Cuboids (in millimeters)

	No. 23165, U. C. Left, *Allodesmus kernensis*	No. 4318, C. A. S. Right, *Allodesmus kernensis*	No. 4319, C. A. S. Left, *Allodesmus kernensis*	No. 4316, C. A. S. Right, *Allodesmus kernensis*	No. 4317, C. A. S. Left, *Allodesmus kernensis*	No. 7140, U. S. N. M. Ad. ♂, *Eumetopias jubata*	No. 21537, U. S. N. M. *Eumetopias jubata*
Greatest dorso-plantar diameter at distal end	39.4	39.9	39.6	34.2	36.0	37.2	30.2
Greatest transverse diameter	38.9	33.8	34.7	29.6	33.8	53.2	37.8
Greatest vertical diameter	57.0	53.7	54.5	45.5	47.4	51.5	41.5
Greatest diameter of facet for ectocuneiform	22.0	21.7	21.8	19.0	20.2	17.0	17.0

for the ectocuneiform, and its long axis is oblique to the vertical axis of the cuboid. There are two small facets for the ectocuneiform on the distal border and between these facets is a deep groove or indentation for the attachment of some ligament. Crossing the cuboid (fig. 57) in an oblique direction below the tuberosity on the plantar face is the groove for the long peroneal tendon. This groove is deeper and more sharply defined on the larger than on the smaller cuboids, but is not as well developed as on the cuboid of *Eumetopias*.

On the distal face, the articular surfaces for the fourth and fifth metatarsals are separated by a sharp crest. These facets correspond in all essential details with those on the cuboid of *Eumetopias jubata*.

Entocuneiform

The meso- and ecto-cuneiforms are not represented in this collection. There are, however, two entocuneiforms from the left side and two from the right. The facets on the entocuneiform and the navicular for articulation with the mesocuneiform show that the latter must have resembled the corresponding tarsal of *Odobenus*. An examination of the pes of the sea lion and the walrus will show that there are some well marked differences in the manner in which these wedge-like bones articulate with one another, and in this connection it is interesting to note that the entocuneiform (fig. 60) of this fossil pinniped is distinguished from the corresponding tarsal of *Eumetopias* by the same characters which ally it with *Odobenus*. As seen from in front these fossil entocuneiforms correspond in shape to those of *Odobenus divergens*, but dif-

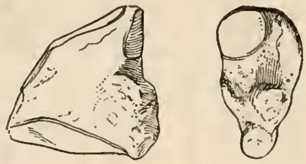
60 61

Left entocuneiform of *Allodesmus kernensis*, No. 4322, C. A. S., × 0.5.
Fig. 60. Dorsal or anterior view. Fig. 61. Internal view.

Measurements for Entocuneiformes (in millimeters)

	No. 4322, C. A. S. Left, *Allodesmus kernensis*	No. 4323, C. A. S. Left, *Allodesmus kernensis*	No. 4324, C. A. S. Right, *Allodesmus kernensis*	No. 11546, U. S. N. M. Right, *Allodesmus kernensis*	No. 1745, U. S. N. M. Left, *Odobenus divergens*	No. 7140, U. S. N. M. Ad. ♂, *Eumetopias jubata*	No. 7141, U. S. N. M. *Eumetopias jubata*
Greatest proximo-distal diameter	48.3	46.9	47.5	40.8	42.4	48.4	34.6
Greatest tibio-fibular diameter	50.6	47.3	47.8	38.+	50.5	44.8	33.3
Greatest dorso-plantar diameter	29.8	27.5+	26.1	22.1	29.3	32.8	23.3
Greatest diameter of facet for navicular	30.8	31.4	32.0	26.2	23.7	44.6	34.2
Greatest diameter of facet for first metatarsal	42.4	40.8	41.0	32.0	48.7	39.4	32.8
Greatest diameter of facet for mesocuneiform	21.2	16.5	17.0	15.+	24.8	....	....
Greatest diameter of facet for sesamoid	22.4	17.1	15.7	15.5	13.4	24.0	17.0

fer in that the slope of the proximal facet is more oblique and that of the distal facet is less oblique. The proximal concave articular surface for the mesocuneiform extends across the fibular face below the facet for the navicular and terminates at the proximo-plantar angle. This detail seems to characterize the entocuneiforms of *Odobenus, Pontolis* cf. *magnus,*[19] and this fossil pinniped.



62 63

Right entocuneiform of *Allodesmus kernensis,* No. 11546, U. S. N. M., × 0.5. Fig. 62. Dorsal or anterior view. Fig. 63. Internal view.

The proximal end of the tibial or internal face (fig. 61) is furnished with a large oval-shaped facet for a sesamoid. Behind this facet the internal surface curves toward the plantar face. A club-shaped and saddle-like articular surface for the first metatarsal occupies the distal end of this tarsal bone. The facet on the proximal end for articulation with the navicular is more or less elliptical in outline and is shallowly concave. The dorsal surface is depressed and pitted as in *Odobenus,* but the plantar surface is more irregular and is furnished with a broad deep groove which terminates at the disto-internal angle. The plantar face of this fossil entocuneiform bears a closer resemblance to the corresponding tarsal of *Eumetopias jubata* than to that of *Odobenus divergens.*

Metatarsals

The fifth metatarsal is represented by four bones of different sizes, ranging from medium to large, and all belonging to a right pes. They exhibit a surprising resemblance to the corresponding metatarsal bone of *Eumetopias jubata.* The size, shape, and extent of the facets on the proximal end are essen-

[19] R. Kellogg, Publ. 348, Carnegie Inst. Washington, 1925, pp. 107-108, text figs. 13-14.

tially the same in both pinnipeds, but the fossil bones have a relatively wider, flattened shaft. As compared with the fifth metatarsal of *Eumetopias*, the curvature of the proximal facet for the fourth metatarsal is much less concave, the facet for articulation with the cuboid has a much lower heel, and the enlarged proximo-plantar angle forms a rounded, inwardly directed protuberance.

Fourth metatarsal bones from the right and left pes likewise agree in essential details with corresponding bones of *Eumetopias jubata.* The proximal end of the shaft is somewhat deeper and there is no constriction between the anterior and proximal facets for articulation with the fifth metatarsal. The shape of the proximal end of this metatarsal is similar to that of *Eumetopias*, but the articular surface is more convex and is continuous internally with facets for the head of the third metatarsal.

A single third left metatarsal is included in the collection, and although the general contour of the proximal end is similar to that of the same bone in *Eumetopias jubata,* it differs from the living sea lion in having an anterior, circular, concave facet and a relatively small posterior facet for articulation with the fourth metatarsal. The internal surfaces for articulation with the second metatarsal agree very closely with that of *Eumetopias*.

Second metatarsal bones of at least three individuals are included in this lot of bones, three of which are from a right pes and a like number from a left pes. The anterior and posterior facets on the proximal end for articulation with the third metatarsal are separated by a rather deep groove. There is nothing to indicate that the second metatarsal articulated with the entocuneiform as in *Eumetopias.* The second metatarsal of *Eumetopias* has a large convex oval facet for articulation with a corresponding articular surface on the entocuneiform. These fossil metatarsals have anterior and posterior facets separated by a broad groove on the internal face of the head, but there is no indication of a corresponding surface on the entocuneiform. There is also a large, oval, concave surface below the posterior facet on the internal surface of the proximal end of the shaft. It would appear that these

facets articulated with the first metatarsal which is not represented in this collection.

Measurements of Metatarsals (in millimeters)

	II C. A. S. No. 4453	III C. A. S. No. 4450	IV C. A. S. No. 4448	V C. A. S. No. 4446	V U.S.N.M. No. 11861
Greatest length..........	89.0	87.+	98.0	93.+	....
Dorso-plantar diameter of head..................	30.4	35.+	41.5	41.+	46.0
Transverse diameter of head.	16.7	21.0	21.8	25.8	27.5
Narrowest transverse diameter of shaft............	12.5	16.9	15.7	14.8	16.8
Transverse diameter of distal end...................	22.0	....	22.8	....	....

7. **Neotherium mirum**[20] Kellogg, new genus and species

Type material: Right calcaneum, No. 11542, U. S. N. M.; right astragalus, No. 11543, U. S. N. M.; right cuboid, No. 11552, U. S. N. M.; left navicular, No. 11548, U. S. N. M.

Referred specimens: Right femur, No. 4300, C. A. S.; left femur, No. 4549, C. A. S.; right humerus, No. 4548, C. A. S.; third metatarsal, No. 4464, C. A. S.; phalanges, Nos. 4573, 4574, C. A. S.; all from **Sharktooth Hill, Kern County, California**; Temblor; Miocene; Charles Morrice, Coll., 1924.

Careful study of the pinniped material collected by Mr. Morrice has led the writer to conclude that at least two distinct types of otariids are present in the middle Miocene, Temblor fauna. This conclusion is based largely upon the structural peculiarities of the tarsal bones. The characters of the tarsal bones are quite constant in living pinnipeds and afford a means for identifying skeletal material. The differences observed between these bones and those referred to *Allodesmus kernensis* seem of generic value. Judging from the proportions of the skeletal elements that are known, this fossil pinniped was no larger and probably smaller than a female *Zalophus californianus*.

[20] νεω, to swim; θηριον, wild beast.

HUMERUS

The fragment of the right humerus (No. 4548, C. A. S.) referred to this pinniped consists of the proximal half of the shaft, but the epiphysis, head, and portions of the deltoid crest are missing. The shaft is narrowed near the middle, arcuate in outline internally, and exhibits a very slight external curvature. The deltoid crest is quite thin and the anterior border does not fold over the external face of the crest as in *Zalophus*.

FEMUR

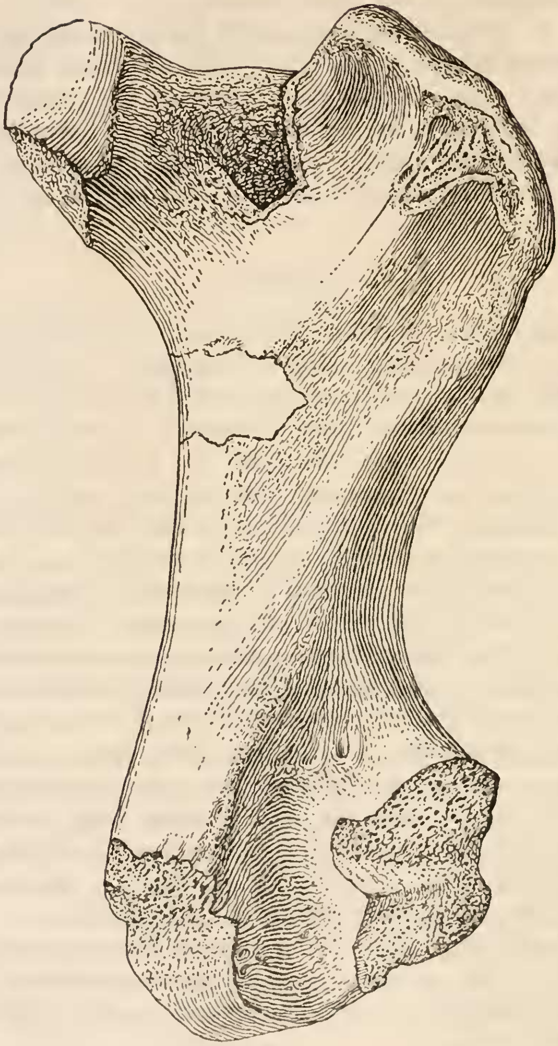
It is unfortunate that the right femur (No. 4300, C. A. S.) referred to this pinniped is badly damaged. The extremities are eroded, the shaft is fractured, and both condyles are missing. A fragment of the distal extremity of a left femur (No. 4549, C. A. S.) of about the same size furnishes some additional information concerning the external condyle and the patellar surface. The shaft of the femur (fig. 64) is rather slender, resembling that of *Zalophus californicus,* but it is fractured traversely at the level of the lesser trochanter, and a section of bone in the region of the latter is missing. The curvature of the broken edges in this region indicates that the lesser trochanter was present. The greater trochanter is large and broad, and the intertrochanteric crest is not developed. The trochanteric fossa is large and quite deep, as is that of *Allodesmus,* whereas in *Zalophus* the fossa is almost obliterated. It is obvious that the neck is rather long as compared with that of *Zalophus*, but most of the head is missing. The intercondyloid fossa is much longer than on the femur of *Zalophus,* but the patellar surface is quite similar.

This fossil femur differs from those of *Zalophus* and *Eumetopias* in (1) the markedly greater transverse diameter of the proximal extremity; (2) the longer neck; and (3) the deeper trochanteric fossa.

Measurements of the Femur

Greatest length of shaft as preserved	136.5 mm.
Greatest transverse diameter of proximal end (head to greater trochanter)	73.+mm.
Least transverse breadth of shaft	31.8 mm.

January 30, 1931

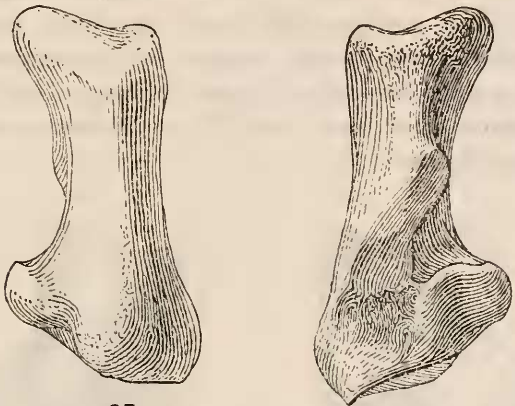


64

Fig. 64. Posterior view of right femur of *Neotherium mirum*, No. 4300, C. A. S., × 1.0.

Calcaneum

In its general features this right calcaneum (No. 11542, U. S. N. M.) is somewhat similar to those of *Arctocephalus australis* (No. 21735, U. S. N. M.) and *Zalophus californianus* (No. 23332, U. S. N. M.). It differs from both, however, in having a more slender shaft, no groove on internal angle of proximal end of shaft, less expanded distal extremity, and no



65 66

Right calcaneum of *Neotherium mirum*, No. 11542, U. S. N. M., × 1.0. Fig. 65. Plantar or posterior view. Fig. 66. Dorsal or anterior view.

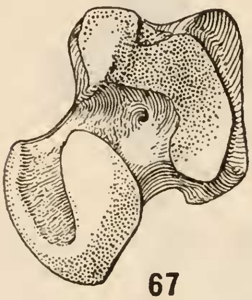
shelf below the sustentacular facet. The ectal facet (fig. 66) is narrow, curved from end to end, and distinctly raised above the shaft. The groove for the interosseous ligament is not sharply defined, but it is quite rugose. The sustentacular facet covers the dorsal face of the greater or internal process. The peroneal tubercle appears to be eroded and the question arises as to whether or not it was traversed by a vertical groove as in *Arctocephalus* or flattened as in *Zalophus*. The concave distal facet for the cuboid is rather small, but occupies most of the distal face of the shaft.

Measurements of the Calcaneum

Greatest length of shaft	52.8 mm.
Greatest dorso-plantar diameter of distal end	16.8 mm.
Greatest tibio-fibular diameter of distal end	28.2 mm.
Greatest diameter of ectal facet	21.0 mm.

Astragalus

This right astragalus (No. 11543, U. S. N. M.) differs from the corresponding tarsal of *Arctocephalus australis* and *Zalophus californianus* in having: (1) a deeper and more saddle-shaped trochlea; (2) a much shorter and less everted external prolongation of the body and consequently a less concave curvature of the fibular facet; (3) postero-superior portion of the body prolonged backward and raised above transverse groove between it and trochlea; (4) a relatively shorter neck; (5) a more convex distal facet for navicular; (6) a narrow crescentic ectal facet; and (7) a shallower groove for interosseous ligament.



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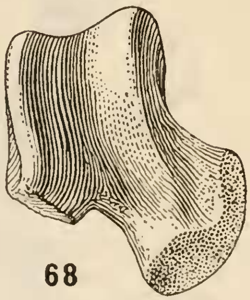

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Right astragalus of *Neotherium mirum*, No. 11543, U. S. N. M., × 1.0. Fig. 67. Plantar or posterior view. Fig. 68. Dorsal or anterior view.

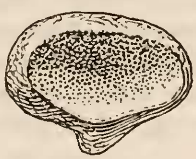
The lateral borders of the trochlea (fig. 68) are rounded and its posterior limits are sharply defined. Although the astragalar foramen is closed, its former position is marked by an irregular depression with numerous minute vascular foramina. The flattened fibular facet is somewhat longer than in either *Arctocephalus* or *Zalophus*. The crescentic ectal facet (fig. 67) is strongly concave and its lower edge is raised above the shallow groove for the interosseous ligament. In the middle of this groove is the closed plantar orifice of the astragalar foramen. The sustentacular facet is slightly convex and its distal margin is cut off from the navicular facet by a shallow tongue-like groove.

Measurements of the Astragalus

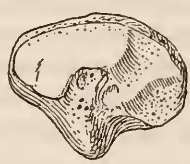
Greatest vertical diameter	39.0 mm.
Greatest transverse diameter	32.0 mm.
Greatest diameter of head	22.2 mm.
Greatest diameter of ectal facet	21.8 mm.
Greatest dorso-plantar diameter of body	26.6 mm.

Navicular

The small left navicular (No. 11548, U. S. N. M.) is rather long, relatively narrow, and quite thin. Differences in relative depth and in curvature of the articular surface for the astragalus distinguish this tarsal from those of *Arctocephalus australis* and *Zalophus californianus*. A rather prominent tuberosity directed toward the fibular side arises from the plantar face. The elliptical facet for the astragalus (fig. 69) is strongly concave in all directions. This navicular lacks a distinct facet for articulation with the cuboid. The facets on the distal face (fig. 70) for the three cuneiforms correspond with those on the navicular of *Arctocephalus australis*. The larger one of these facets rests upon the entocuneiform and is separated from the smaller medial facet for the mesocuneiform by a raised ridge, and the latter in turn merges with the



69



70

Left navicular of *Neotherium mirum*, No. 11548, U. S. N. M., × 1.0. Fig. 69. Proximal view. Fig. 70. Distal view.

obliquely placed facet for the ectocuneiform. Between the plantar tuberosity and the above mentioned facets is a roughened area for the interosseous ligament.

Measurements of the Navicular

Dorso-plantar diameter	18.9 mm.
Tibio-fibular diameter	.24.6 mm.
Greatest vertical diameter	11.2 mm.

Cuboid

The right cuboid (No. 11552, U. S. N. M.) is relatively large and its configuration is more like that of *Pontolis* cf. *magnus*[21] than that of any living otariid. On the proximal end of the cuboid is a large articular facet, curving obliquely forward and outward from the interno-plantar angle, which supports the calcaneum. The extero-plantar angle of this facet

71 72 73

Right cuboid of *Neotherium mirum*, No. 11552, U. S. N. M., × 1.0. Fig. 71. Dorsal or anterior view. Fig. 72. Plantar or posterior view. Fig. 73. Tibial view.

is extended over upon the base of the prominent plantar tuberosity. This facet is continuous internally with the sub-vertical concave facet for the astragalus. The postero-external tuberosity is greatly produced and its distal face is traversed by the sharply defined broad groove for the *peroneus longus*. A ridge-like internal continuation of this tuberosity (fig. 72) extends across the plantar face, but it diminishes rapidly in height.

On the internal or tibial face (fig. 73) is a large proximal articular surface for the astragalus, navicular, and ectocuneiform. Two small facets for the ectocuneiform separated by a deep notch are likewise present on the distal border of the internal face.

Distally there is a curved articular surface for the proximal ends of the fourth and fifth metatarsals, the facet for the fifth metatarsal being situated on the extero-plantar angle.

[21] R. Kellogg. Structure of the flipper of a Pliocene pinniped from San Diego County, California. Publ. 348, Carnegie Inst. Washington, 1925, pp. 106-107, fig. 12.

Measurements of the Cuboid

Greatest proximo-distal diameter	34.3 mm.
Greatest median dorso-plantar diameter	25.4 mm.
Greatest tibio-fibular diameter	23.3 mm.

Metatarsal

The proximal end of a third right metatarsal (No. 4464, C. A. S.) is referred to this pinniped. It has a rather narrow facet for articulation with the ectocuneiform. On the extero-anterior angle of the head is a circular concave facet for articulation with the fourth metatarsal. The shaft is deeply excavated between the outwardly turned posterior angle of the head and the above described facet. There is a prominent convex articular surface for the second metatarsal on the anterior angle of the head. The shaft is rather slender and almost cylindrical below the head.

Phalanges

Two slender phalanges (Nos. 4573, 4574, C. A. S.) are thought to belong to this pinniped. The metatarsal and these two phalanges are similar in their proportions to the corresponding bones of *Callorhinus alascanus*. The shorter of these two phalanges has an expanded distal extremity and may have been the middle phalanx of the first digit, while the other one tapers from the base to the extremity and corresponds in its proportions to the proximal phalanx of the fifth digit. One measures 50 mm. and the other 41 mm. in length.

Order CETACEA

Three species of cetotheres, a sperm whale, a shark-toothed porpoise, and nine other species of porpoises are recognized in the cetacean remains from the Temblor formation. This is the largest fauna of cetaceans thus far known for any formation on the Pacific Coast of North America. One incomplete skull and the fragments of another skull show the stage of telescoping present in one of the cetotheres. Fragments of the cranium in addition to the ear bones indicate the presence of a second species. The third cetothere is known only from a single periotic bone. Other skeletal elements belonging to

cetotheres are included in the collection. There are a number of incomplete bullæ, in most cases the involucrum alone, which are not referred to any particular cetothere. Some of the limb bones are referred tentatively to these cetotheres, but no attempt has been made to allocate the incomplete and eroded vertebræ which unquestionably belong to one or another of these archaic whalebone whales.

It is recognized that adequate material is not available to settle the relationships of many of the porpoises. It is sufficient, however, to indicate the presence of a number of distinct species. The sperm whale is fairly well represented by skeletal elements, for we have the skull of an adult, portions of the skull of a young individual, and a number of ear bones. The new species of porpoises hereinafter described are based solely upon the periotics, since the writer has found that these ear bones are quite diagnostic. Mention is made of other skeletal elements belonging to odontocetes, and some of these bones are figured and described, although in most instances they are not referred to any particular porpoise. They are described merely as a matter of record and it is hoped that future collecting will provide the material for an adequate discussion of the characters of the several species of porpoises represented in the Temblor fauna.

Suborder Mysticeti

Family CETOTHERIIDÆ: Cetotheres

At least three different kinds of cetotheres are included among the cetacean bones collected by Mr. Morrice at Sharktooth Hill. A considerable portion of the skull, with the ear bones of the right side attached to it, forms the basis for one of these species; fragments of the hinder portion of the skull and the right periotic represent a second species; and an imperfect left periotic bone indicates the presence of a third species. Complete, as well as fragmentary cetothere limb bones of various sizes were sorted out of this collection. The bones of many kinds of fossil pelagic mammals were found scattered about in this bone bed, and it is unfortunate that none of the skeletal elements of the cetotheres were associated with skulls. Hence the allocation of these limb bones to any

one of the above mentioned cetotheres may appear more or less arbitrary, but nevertheless they were critically compared with the corresponding bones of cetotheres found elsewhere and it is believed that the present disposition is as nearly accurate as one can hope to accomplish by using comparative measurements and other available data. Vertebræ of several sizes, and from different parts of the column, which undoubtedly belong to cetotheres, were also obtained by Mr. Morrice. After some study it was decided to omit any discussion of these vertebræ because of the difficulty of allocating these bones with any degree of certainty to any particular species. Not one of the atlases fitted the condyles of the cetotheres hereinafter described. Vertebræ, especially those from the cervical and caudal regions, of fossil porpoises exhibit a considerable range of variation, and it is not unlikely that those of the larger whales are equally, if not more, variable. The criteria employed for the classification of the mysticetes depend upon the relations of the bones which comprise the skull and before entering into a detailed discussion of these Temblor cetotheres it is desirable to summarize the diagnostic characters of the families Cetotheriidæ and Balænopteridæ.

Miller's opinions[22] in regard to the diagnostic characters of the families Cetotheriidæ and Balænopteridæ are in so close accord with my own that they are repeated to clarify the discussion of the various genera, which are referred to these families.

In both families the telescoping of skull is accomplished by a combined forward movement of posterior elements and a backward movement of anterior elements, which at least produces some interdigitation of rostral and cranial elements. The nasals and ascending processes of premaxillaries are not situated entirely anterior to the level of the orbital wings of the frontals; and a definite ascending process of the maxillary is always present.

In the Cetotheriidæ the parietal is entirely behind the posterior level attained by nasals and ascending processes of maxillaries and premaxillaries; the occipital shield does not extend forward over level of orbit, or beyond anterior level attained by articular portion of squamosal; the frontal is

[22] G. S. Miller, Jr., Smithson. Misc. Coll., vol. 76, publ. 2720, 1923, pp. 21-22.

broadly exposed on interorbital region; the expanded lateral (articular) portion of squamosal is relatively small, and its under surface is not deeply concave. The supraorbital process of frontal slopes gradually downward and outward from the level of the dorsal surface of interorbital region; the parietals come in contact, or nearly so, on the vertex between the occipital shield and the frontal; the nasals are small (normal), their combined dorsal area equaling much less than half that of supraorbital portion of frontal; the rostrum tends toward breadth rather than depth; the mandible is slender and conspicuously bowed outward.

In the Balænopteridæ the parietal extends forward laterally beyond posterior level attained by nasals and ascending processes of maxillaries and premaxillaries; the occipital shield extends forward over level of orbit and beyond the anterior level attained by the articular portion of squamosal; the frontal is scarcely or not exposed on interorbital region; the expanded lateral (articular) portion of squamosal is relatively large, its under surface being deeply concave; the supraorbital process of frontal is abruptly depressed at base to a level noticeably below that of dorsal surface of interorbital region; the rostrum tends toward breadth rather than depth; the mandible is conspicuously bowed outward.

In view of the present confusion prevailing in the application of generic names to fossil whalebone whales, it seemed desirable to fix the genotypes of those that include several species. In each instance, where it was necessary to fix the genotype from several species listed by the author when the generic name was proposed, a species founded upon a skull was chosen, if possible.

Genotypes of Genera of Fossil Whalebone Whales Belonging to the Families Cetotheriidæ and Balænopteridæ

Middle Oligocene

Pachycetus, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (3), vol. 6, No. 7, 1883, pp. 31-32. [Genotype, here designated as *Pachycetus robustus,* Van Beneden, 1883; Rupelian stage; "dans le couches phosphatées très connues de Helmstedt (Bas Brunswick). — entre l'Elbe et le Weser. — un sable vert glauconifère"; Museum für Mineralogie, Geologie und Vorgeschichte, Dresden, Germany.]

Upper Oligocene

Cetotheriopsis, Brandt, Bull. Acad. Imp. Sci. St. Petersbourg, vol. 16, 1871, p. 566. [Genotype, *Balænodon lintianus,* Meyer, 1849; Aquitanian or I. Mediterranean stage; white marine sands in the vicinity of Linz, Austria. *Stenodon,* Van Beneden, 1865 (preoccupied), and *Aulocetus,* Van Beneden, 1875, have the same genotype as *Cetotheriopsis;* Museum Francisco-Carolinum, Linz, Upper Austria.]

Lower Miocene

Palæobalæna, Moreno, Rev. Mus. La Plata, vol. 3, 1892, p. 394. [Genotype, *Palæobalæna bergi,* Moreno, 1892; Langhian Stage; Santa Cruz beds at Misioneros, Patagonia, Argentine Republic; Museum at La Plata.]

Upper Miocene

Cephalotropis, Cope, Science, n. s., vol. 3, 1896, p. 880; *idem,* Proc. Amer. Philos. Soc., vol. 35, no. 151, 1896, pp. 141, 143-145. [Genotype, *Cephalotropis coronatus,* Cope, 1896; Yorktown formation (= St. Marys); probably from Chesapeake region, eastern United States; United States National Museum.]

Cetotheriomorphus, Brandt, Mem. Acad. Imp. Sci. St. Petersbourg (7), vol. 20, no. 1, 1873, pp. ii, 161-162, pl. 23, figs. 4-8. [Genotype, *Cetotheriomorphus dubius,* Brandt, 1873; locality unknown, possibly southern Russia; Museum of the Imperial Institute of Mines, St. Petersbourg.]

Cetotherium, Brandt, L'Institut, Paris, vol. 11, no. 499, 1843, p. 241, and no. 502, p. 270. [Genotype, *Cetotherium rathkii,* Brandt, 1843; Sarmatian stage; Steppe limestone; Kertsch near promontory Takali, southern Russia; Museum of the Imperial Academy of Sciences, St. Petersbourg.]

Eucetotherium, Brandt, Mem. Acad. Imp. Sci. de St. Petersbourg (7), vol. 20, no. 1, 1873, p. 143. [Genotype, here designated as *Cetotherium helmersenii,* Brandt, 1873, *op. cit.,* p. 95, pl. 6; Sarmatian stage; limestone; near the promontory Pekla on the coast of the Black Sea, Crimea, Russia; Museum of Imperial Institute of Mines, St. Petersbourg.]

Herpetocetus, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 34, no. 7, 1872, p. 247. [Genotype, *Herpetocetus scaldiensis,* Van Beneden, 1872; Bolderien stage; sables inferieurs d'Anvers; du nouveau canal d'Herenthals, troisieme section, partie de Stuyvenberg, environs of Antwerp, Belgium; Musée Royal d'Histoire Naturelle de Belgique, Bruxelles.]

Isocetus, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 50, 1880, pp. 24-25. [Genotype, *Isocetus De Pauwii,* Van Beneden, 1880; Bolderien stage; sables; environs of Antwerp, Belgium; Musée Royal d'Histoire Naturelle de Belgique, Bruxelles.]

Mesocetus, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 50, no. 7, 1880, pp. 22-23. [Genotype, *Mesocetus longirostris,* Van Beneden, 1880; Bolderien stage; sables; environs of Antwerp, Belgium; Musée Royal d'Histoire Naturelle de Belgique, Bruxelles.]

Mesoteras, Cope, Amer. Nat. vol. 4, 1870, p. 128. [Genotype, *Mesoteras kerrianus,* Cope, 1870; (?) Yorktown formation; marl, Quanky Creek, Roanoke River, Halifax County, North Carolina (possibly near town of Halifax, about 30 miles south of northern boundary of North Carolina, and south of towns of Roanoke Falls & Weldon); United States National Museum and the State Museum, Raleigh, North Carolina.]

Metopocetus, Cope, Proc. Amer. Philos. Soc., vol. 35, no. 151, 1896, p. 141. [Genotype, *Metopocetus durinasus,* Cope, 1896; Calvert formation; marl near the mouth of the Potomac River, Maryland; United States National Museum.]

Pachyacanthus, Brandt, Bull. Acad. Imp. Sci. St. Petersbourg, vol. 16, 1871, pp. 564-565; and *idem,* Mem. Acad. Imp. Sci. St. Petersbourg (7), vol. 20, no. 1, 1873, pp. 166-169, pls. 14-17. [Genotype, here designated as, *Pachyacanthus suessii,* Brandt, 1871; Sarmatian stage; Tegel von Nussdorf, Vienna basin, Austria; Naturhistorischen Staatsmuseum, Wien, Austria.]

Parietobalæna, Kellogg, Proc. U. S. Nat. Mus., vol. 63, publ. 2483, 1924, p. 1. [Genotype, *Parietobalæna palmeri,* Kellogg, 1924; Calvert formation; greenish sandy clay; 1 mile north Dare's wharf, Calvert County, Maryland; United States National Museum.]

Rhegnopsis, Cope, Proc. Amer. Philos. Soc., vol. 35, no. 151, 1896, p. 145. [Genotype, *Balæna palæatlantica,* Leidy, 1851; St. Marys formation; City Point, Prince George County, Virginia. *Protobalæna,* Leidy, 1869 (preoccupied), has the same genotype; Academy of Natural Sciences of Philadelphia.]

Siphonocetus, Cope, Proc. Amer. Philos. Soc., vol. 34, no. 147, 1895, pp. 140-141, pl. 6, figs. 3-5. [Genotype, *Balæna prisca,* Leidy, 1851; St. Marys formation; Westmoreland County, Virginia; Academy of Natural Sciences of Philadelphia.]

Tretulias, Cope, Proc. Amer. Philos. Soc., vol. 34, no. 147, 1895, pp. 143-145, pl. 6, fig. 2. [Genotype, *Tretulias buccatus,* Cope, 1895; "Yorktown"; possibly Maryland or Virginia; United States National Museum.]

Ulias, Cope, Proc. Amer. Philos. Soc., vol. 34, no. 147, 1895, pp. 141-143, pl. 6, fig. 1. [Genotype, *Ulias moratus,* Cope, 1895; "Yorktown"; possibly Maryland or Virginia; United States National Museum.]

Lower Pliocene

Amphicetus, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 50, no. 7, 1880, pp. 20-21. [Genotype, here designated as, *Amphicetus later,* Van Beneden, 1880; Diestien stage; sables; environs of Antwerp, Belgium; Musée Royal d'Histoire Naturelle de Belgique, Bruxelles.]

Cetotheriophanes, Brandt, Mem. Acad. Imp. Sci. de St. Petersbourg (7), vol. 20, no. 1, 1873, pp. 148-149, 156-157, pl. 20, figs. 13-16. [Genotype, here designated as, *Cetotherium (Cetotheriophanes) cuvieri,* Brandt, 1873 = *Balæna cuvieri,* Fischer, 1829, Synopsis Mammalium, p. 527; Plaisancian stage; marna argillosa cerulea; Monte Pulgnasco, Italy; Museo civico di Milano, Italy.]

Heterocetus, Van Beneden, Bull. Acad. Roy. Sci. Belgique (2), vol. 50, no. 7, 1880, pp. 21-22. [Genotype, here designated as, *Cetotherium brevifrons,* Van Beneden, 1872; Diestien stage; sables moyens d'Anvers, Belgium; Musée Royal d'Histoire Naturelle de Belgique, Bruxelles.]

Megapteropsis, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 34, no. 7, 1872, p. 242. [Genotype, *Megapteropsis robusta,* Van Beneden, 1872; Diestien stage; sables moyens d'Anvers; Eeckeren and Wyneghem, near Antwerp, Belgium; Musée Royal d'Histoire Naturelle de Belgique, Bruxelles.]

Notiocetus, Ameghino, Revista Argentina Hist. Nat., vol. 1, entrega 3a, 1891, p. 167, fig. 75. [Genotype, *Notiocetus romerianus,* Ameghino, 1891; Pontian; Pampean formation, Bahia Blanca, Argentine Republic.]

Plesiocetopsis, Brandt, Mem. Acad. Imp. Sci. St. Petersbourg (7), vol. 20, no. 1, 1873, pp. 143-146. [Genotype, here designated as, *Plesiocetus hupschii,* Van Beneden, 1859; Diestien stage; sables; Saint Nicolas, environs of Antwerp, Belgium; Musée de l'Université Catholique, Louvain.]

Plesiocetus, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 8, no. 11, 1859, p. 139. [Genotype fixed as, *Plesiocetus garopii* by Van Beneden, 1872, Bull. Acad. Roy. Sci. Belgique (2), vol. 34, p. 242; Diestien stage; sables; Saint Nicolas, environs of Antwerp, Belgium; Musée de l'Université Catholique, Louvain.]

MIDDLE PLIOCENE

Burtinopsis, Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 34, no. 7, 1872, p. 246. [Genotype, *Burtinopsis similis,* Van Beneden, 1872; Scaldisien stage; sables; environs of Antwerp, Belgium; Musée Royal d'Histoire Naturelle de Belgique, Bruxelles.]

Idiocetus, Capellini, Atti R. Accad. dei Lincei, Roma (2), vol. 3, pt. 2, 1876, pp. 12-13; *idem,* Mem. R. Accad. Sci. Bologna, (6) vol. 2, 1905, pp. 71-80, pls. 1-2. [Genotype, *Idiocetus guicciardinii,* Capellini, 1876; Astian stage; argilla turchina; Montopoli nel Valdarno inferiore, Tuscany, Italy; Museo di Geologia e di Paleontologia, Firenze, Italy.]

UPPER PLIOCENE

Palæocetus, Seeley Geol. Mag., London, vol. 2, no. 8, 1865, pp. 54-57, pl. 3. [Genotype, *Palæocetus sedgwickii,* Seeley, 1865; (?) Red Crag; Roswell Pit, in boulder clay of Ely, near Cambridge, England. (See Lydekker, Cat. Foss. Mamm. Brit. Mus., pt. 5, 1887, p. 31.)]

Something like 15 generic names have been proposed for fossil cetotheres from the upper Miocene, whereas but one species of lower Miocene age has been honored with a distinct generic name. Turning to the Pliocene we find that the two families, Cetotheriidæ and Balænopteridæ, are represented by seven genera in the lower Pliocene, one in the middle Pliocene, and two in the upper Pliocene, excepting of course those genera which have living representatives.

The skull of the upper Oligocene *Cetotheriopsis*[23] is characterized in part by a high, narrow supraoccipital shield curving more forward than upward and divided mesially by a long vertical carina, elongate zygomatic processes not reaching forward to the level of the apex of the supraoccipital shield, and the vertex of the braincase, viewed from behind, being strongly depressed below the arching lambdoid crests.

Of the 15 upper Miocene genera, the genotypes of six (*Herpetocetus, Isocetus, Rhegnopsis, Siphonocetus, Tretulias,* and *Ulias*) were based wholly or in part upon mandibles, the remainder of the skulls being unknown. Critical comments on the validity of those that were founded on mandibles are given by Winge[24] and True.[25] Vertebræ constitute the basis for the Austrian genus *Pachyacanthus*. The status of the Russian genus *Cetotheriomorphus* is as doubtful as its specific name implies, for it was founded upon a single small lumbar vertebra without epiphyses or neural spine. For the remaining genotypes portions at least of skulls were available to the original describer.

Five species, *rathkii, klinderi, helmersenii, priscum,* and *mayeri* were originally included in the subgenus *Eucetotherium.* Since *rathkii* is the genotype of *Cetotherium,* the species *helmersenii* may be selected as the genotype of *Eucetotherium,* for it is the only one of the four remaining species which is based in part upon a braincase. The architecture of the skull, in so far as it is preserved, is not materially different from that of *Cetotherium rathkii.* In reviewing the literature, we find that the generic names *Cetotherium* and *Plesiocetus*

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[23] J. F. Brandt. Mem. Acad. Imp. Sci. St. Petersbourg, (7), vol. 20, no. 1, 1873, pl. 19, figs. 1-4.

[24] H. Winge, Vidensk, Meddel. naturhist. Foren. i. Kjobenhavn, 1909, pp. 1-37, pls. 1-2.

[25] F. W. True. Smithson. Misc. Coll., vol. 59, publ. 2081, 1912, pp. 1-8.

have been used rather indiscriminately for fossil whalebone whales of Miocene and Pliocene age, some of which unquestionably belong in the family Balænopteridæ.

Skulls of the Miocene genera *Cetotherium, Cephalotropis, Mesocetus, Metopocetus,* and the Pliocene *Amphicetus* have a rather short intertemporal region, and the lateral lambdoid crests are continued through a short sagittal crest with anterior temporal crests which diverge anteriorly and gradually disappear on the base of the corresponding supraorbital process. The anterior limits of the temporal muscles on these skulls were sharply defined by these strong temporal crests. Winge[26] obviously was mistaken in concluding that the skulls of all extinct finbacks have a temporal crest similar to that of *Cephalotropis coronatus* Cope, for there are quite a number, including *Plesiocetopsis megalophysum* and *Parietobalæna palmeri,* which either lack sharply defined temporal crests or do not exhibit any trace of them. In all of these fossil cetotheres the backward thrust of the mesial portion of the rostrum has carried the ascending processes of the maxillæ and premaxillæ, as well as the nasals, beyond the level of the preorbital angles of the supraorbital processes.

Van Beneden[27] has already pointed out that the genus *Cetotheriophanes* was founded on an error in observation on the part of Brandt, for the scapula of the species *cuvieri* is mutilated. The skull of the genotype, *Balæna cuvieri,* is exceptionally well preserved and presents all the diagnostic features of the family Balænopteridæ. The structural peculiarities of the skull do not warrant the retention of Brandt's generic name. Balsamo Crivelli[28] apparently was the first author to place this species in its proper genus and it appears in his memoir as *Balænoptera cuvieri.*

The genotypes of *Megapteropsis* and *Burtinopsis* are large species and appear to be related to the living humpback whale *(Megaptera).* The mandibular and cranial fragments, which formed the basis for *Mesoteras kerrianus,* are equal in size to the corresponding portions of the largest of the living fin-

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[26] H. Winge, *op. cit.,* p. 28.

[27] P. J. Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 20, no. 12, 1875, p. 3.

[28] G. Balsamo Crivelli, Gior. d' I. R. Inst. Lombardo Sci., Let. ed Arti, vol. 2, no. 9, 1842, pp. 133-138.

backs. Unfortunately a few fragments constitute all that is known of the skull of *Idiocetus guicciardinii*, but the earbones are sufficiently diagnostic to show that this genus belongs in the family Balænopteridæ.

By employing this method of elimination in conjunction with diagnostic criteria, we find that there are three genera which should be critically examined to determine their relationships to the Temblor cetothere. These genera, so far as can be judged by the illustrations of skulls representing them, exhibit affinities, more or less close, with the Temblor cetothere. The genotypes of two of these cetotheres, *Heterocetus* and *Plesiocetopsis*, belong to the lower Pliocene, but that of *Parietobalæna* comes from the middle Miocene.

Bones found during the excavations for the gas reservoir north of the village of Saint-Nicolas, Belgium, in separate groups at a depth of 4 meters and almost at the level of the clay in the lower zone of the super-clayey quick sand, formed the basis for the three species, *hupschii*, *burtinii*, and *garopii*, which Van Beneden proposed to include in his new genus *Plesiocetus*. Some of these specimens were found on July 30, 1859, and the remainder a few days later. These specimens apparently were deposited in the museum of the Catholic University at Louvain. Van Beneden stated that the species of *Plesiocetus* are distinguished from other whalebone whales by their free vertebræ, by their having a scapula with a rudimentary coracoid process and well developed acromion situated high up and directed obliquely, and by a pyruliform tympanic bulla with an angular external surface. He also concluded that the skull suggests a whale with a more robust and less tapering head.

This diagnosis, however, is based chiefly on species which were later excluded from the genus *Plesiocetus*. In 1872, Van Beneden[29] explicity stated that the generic name *Plesiocetus* is retained solely for *Plesiocetus garopii*, a whale of large size and very close to the living *Balænoptera*, and that the other originally included species are allocated to *Cetotherium*. By this action, Van Beneden definitely fixed the species *garopii* as the genotype of *Plesiocetus* and all subse-

[29] P. J. Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 34, no. 7, 1872, p. 242.

quent opinions of Van Beneden and others do not alter the status of *Plesiocetus garopii.* The present writer[30] overlooked this action by Van Beneden and designated the type of *Plesiocetus* as *Plesiocetus hupschii.*

It is interesting to note, however, that Van Beneden[31] in October, 1877, stated that the illustrations for the three species of *Plesiocetus (garopii, burtinii,* and *hupschii)* were prepared before the specimens in the museum at Brussels were put at his disposal, and that the study of this material had caused him to change some of his previous determinations. The volume dealing with the genus *Plesiocetus*[32] appeared in 1885, and in it Van Beneden apparently reconsidered his previously published opinion and returned the species excluded in 1872 to the genus *Plesiocetus,* but he failed to mention what disposition was made of *Plesiocetus garopii.* It is apparent that the generic name *Plesiocetus* is not available for the group of cetotheres formerly associated together under this name.

A year later when Brandt[33] published his memoir on the cetaceans of Europe, he concurred with the action of Van Beneden in 1872 and excluded all but *Plesiocetus garopii* from the genus *Plesiocetus.* In this memoir Brandt proposed a new subgenus, *Plesiocetopsis,* for *Cetotherium,* and included in this new group *Plesiocetus hupschii, Cetotherium brevifrons, Cetotherium dubium, Plesiocetus burtinii,* and *Plesiocetus gervaisii.* One *(Cetotherium brevifrons)* of these five species was referred by Van Beneden[34] in 1880 to the genus *Heterocetus,* and the present writer has selected this species for the type of that genus. Of the four species which remain, two alone *(hupschii* and *burtinii)* are represented by adequate cranial material. The second *(P. burtinii),* orginally included in Van Beneden's genus *Plesiocetus,* is somewhat larger than *P. hupschii,* having an estimated length of 5 meters. Van Beneden states that he recognized portions of 4 individuals (axes) among the remains which formed the basis for *Plesiocetus*

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[30] R. Kellogg, Publ. 348, Carnegie Inst. Washington, 1925, p. 51.

[31] P. J. Van Beneden and P. Gervais, Ostéographie des Cétacés, Paris, text, 1877, p. 612, footnote.

[32] P. J. Van Beneden, Description des Ossements Fossiles des environs d'Anvers. Pt. 4. Cétacés. Genre: Plesiocetus. Ann. du Mus. Roy. d'Hist. Nat. de Belgique, vol. 9, 1885, pp. 1-40, pls. 1-30.

[33] J. F. Brandt, Mem. Acad. Imp. Sci. St. Petersbourg (7), vol. 20, no. 1, 1873, pp. iii, 165.

[34] P. J. Van Beneden, Bull. Acad. Roy. Sci. Belgique, (2), vol. 50, 1880, p. 22.

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burtinii. No braincase was included among the co-types, and the complete list of specimens as given by Van Beneden is as follows: 2 squamosal bones, a nearly complete mandible, 2 tympanic bullæ, atlas and axis (nearly complete) and 3 other cervicals, the first 3 dorsals, many lumbars, 3 caudals, many ribs, 2 incomplete scapulæ, a humerus, and a radius. About 12 years later, Van Beneden[35] figured some of these specimens. Whatever disposition may ultimately be made of this species, much depends upon its relationships to specimens subsequently referred to it.

Among the specimens described and figured in 1885 is the braincase[36] of a cetothere (Cat. No. 127) in the Royal Museum at Brussels. Van Beneden considered it to be an example of *Plesiocetus burtinii.* This cranium is, therefore, a referred specimen and may or may not be identical with the original type material. It seems advisable, therefore, to select one of the other originally included species as the genotype of *Plesiocetopsis.* Upon comparing the illustrations of the braincase of *P. burtinii* with those of other cetotheres, it became apparent that the Belgian species is surprisingly like that of *Parietobalæna palmeri* in some respects. This resemblance is especially striking when the skulls are viewed from behind. Both skulls are characterized by the regular curvature of the lambdoid crests, by large postglenoid processes, and by small, wing-like exoccipitals. The periotic bones are quite unlike those of *Parietobalæna.* The precise relationships of *Plesiocetopsis burtinii* will remain uncertain until the characters of the dorsal and ventral surfaces are determined. In so far as one can judge from available illustrations, this braincase differs from the Temblor skull in the shape of the supraoccipital shield.

In view of these facts, *Plesiocetus hupschii* may be designated as the type of Brandt's subgenus *Plesiocetopsis,* which is hereinafter raised to full generic rank. Portions of two skeletons of a cetothere, whose length was estimated as being from 3 to 3½ meters, formed the basis for *Plesiocetopsis hupschii.* Van Beneden specifically mentions a basicranium intact as far

[35] P. J. Van Beneden and P. Gervais, Ostéographie des Cétacés, Paris. Text, 1872, p. 284; Atlas, 1872, pl. 16, figs. 10-16.

[36] P. J. Van Beneden, Ann. Mus. Roy. d'Hist. Nat. Belgique, vol. 9, 1885, pl. 28, fig. 1; pl. 29, fig. 1.

as the sphenoid, both condyles nearly complete, and a squamosal with a well preserved zygomatic process. The second specimen consists of the occipital portion of the skull with condyles, and the corresponding portion of an atlas. This specimen is said to belong to a slightly larger individual. Four or five vertebræ and fragments of ribs, belonging to an animal of the same size, are also mentioned. The basicranium was figured by Van Beneden,[37] and reference is made to this illustration by Brandt[38] in 1873. The skull figured by Van Beneden[39] in 1885 is deposited in the Royal Museum at Brussels and bears the catalogue number 1239. The basicranium mentioned in 1859, and figured in 1872, by Van Beneden is one of the co-types, and should not be confused with the Brussels museum skull, referred in 1885 to *Plesiocetus hupschii.* All comparisons hereinafter made are based on the co-type figured in the Ostéographie des Cétacés.

An outstanding peculiarity of the basicranium of *Plesiocetopsis hupschii* is the presence of a robust process with a large concavity in the area corresponding to the paroccipital process. Muscles arising from the atlas and thorax in recent balænopterine whales are inserted upon the paroccipital process and adjoining surface of exoccipital bone. One might infer from analogous conditions in living mammals that these muscles had had tendinous insertions on this fossil skull. This, in turn, would seem to indicate that more freedom of movement was permitted to the head of this fossil whale than is the case in recent balænopterine whales. Assuming that the basicranium of *Plesiocetopsis hupschii,* the exact dimensions of which were not published, was carefully depicted by the artist, there is no reason to suppose that it differed in any fundamental respect from the skull which Cope named *Cetotherium megalophysum,* for the relative proportions of the component parts are essentially the same in both species. These two skulls, however, differ from one another sufficiently to warrant their being referred to distinct species of the genus *Plesiocetopsis.*

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[37] P. J. Van Beneden and P. Gervais, Ostéographie des Cétacés, Paris, Atlas, 1872, pl. 16, fig. 17.

[38] J. F. Brandt, Mem. Acad. Imp. Sci. St. Petersbourg (7), vol. 20, no. 1, 1873, p. 144.

[39] P. J. Van Beneden, Ann. Mus. Roy. d'Hist. Nat. Belgique, vol. 9, 1885, pl. 21, fig. 1.

In the matter of relative proportions, the antero-posterior diameter of the temporal portion of each of these basicrania, as measured from the anterior margin of the squamosal in the temporal fossa to the posterior margin of the exoccipital, is nearly one-third greater than that of the Temblor skull. The skulls of the St. Marys and Belgian cetotheres have large condyles, the exoccipitals are extremely thick bones, and the position of the *foramen ovale* with respect to the temporal margin of the squamosal is approximately the same in both. Furthermore, the periotic bones of these two fossil skulls have the same general type, and they exhibit a striking resemblance to the periotic of the Temblor cetothere.

One analogous feature of the braincase of *Heterocetus brevifrons*[40] and the Temblor skull, is the height and extent of the forward thrust of the supraoccipital shield. If the restoration suggested by Van Beneden is correct, the apex of the supraoccipital shield projects forward beyond the level of the extremities of the zygomatic processes. The apical portion of this shield is smooth, apparently slightly depressed, and there is no indication of a vertical carina such as is found on the Temblor skull. I have been informed by A. Brazier Howell that this carina may suggest more differentiation of the muscles attached to the supraoccipital shield and possibly allow them more independent movement. The condyles of the Belgian skull are relatively large, the distance between their outside margins being equivalent to about one-fourth of the breadth of the skull across the zygomatic processes. The intertemporal region is short and the sagittal crest appears to be somewhat worn. The lateral extension of the exoccipital, the downward prolongation of the postglenoid process, and the curvature and development of a crest on the posterior margin of the squamosal are in close agreement with similar portions of the Temblor skull. One of the most obvious structural peculiarities of the *Heterocetus brevifrons* braincase seems to have been overlooked by previous investigators, if the illustration used by Van Beneden has been correctly interpreted. There seems to be a deep fossa in the squamosal on the internal face of the zygomatic process above the glenoid articular surface. This

[40] P. J. Van Beneden, Ann. Mus. Roy. d'Hist. Nat. Belgique, vol. 13, 1886, pl. 25, fig. 1; pl. 26, fig. 1; pl. 27, fig. 1.

fossa will be discussed more fully in a forthcoming paper on a cetothere skull from the Calvert formation of Maryland. This feature alone would remove any possibility of generic relationship with the Temblor cetothere.

Parietobalæna is the only Miocene genus, for which a skull is known, that is anywhere nearly contemporaneous with the cetothere from the Temblor formation hereinafter described, and both of these skulls lack shaply defined anterior temporal crests. In so far as our present knowledge goes, the Temblor skull is separable from *Parietobalæna* by a combination of characters which may have no great importance. Aside from differences observable in the periotic bones of these two fossil cetotheres, the skull of *Parietobalæna* differs from the Temblor cetothere in having much more slender and more incurved zygomatic processes, a more triangular supraoccipital shield, prominent subhemispherical protuberances with obliquely placed concavity on lateral margins of the basioccipital, and exoccipitals with much thinner extremities.

Our present knowledge of these small Miocene whalebone whales would seem to indicate that no generic name is available for the Temblor cetothere which in some respects resembles *Plesiocetopsis* and in others *Parietobalæna*.

8. **Tiphyocetus temblorensis**[41] Kellogg, new genus and species

Holotype: No. 4355, Mus. Calif. Acad. Sci. from **Sharktooth Hill, Kern County, Cal.**; Temblor, Miocene; Charles Morrice, Coll., 1924. The type skull consists of an incomplete braincase in a fair state of preservation. The left side of the cranium, with its zygomatic process and the supraorbital processes of both frontals, is missing. Portions of the rostrum were found associated with this braincase. The right tympanic bulla and periotic are attached to the skull.

Referred specimens: No. 4357, C. A. S., portions of a disarticulated skull in a fair state of preservation, the most important pieces of this skull being the basicranium, the presphenoid and posterior end of the vomerine trough, and the right squamosal region; No. 4425, C. A. S., condyles and basi-

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[41] Τιφυς, pilot of the Argo; κητος, whale.

cronium; No. 4440, C. A. S., vertex of supraoccipital and sagittal portion of parietals; No. 4439, C. A. S., both exoccipitals, and fragment of basicranium with left pterygoid fossa; No. 4353, C. A. S., right periotic; No. 4354, C. A. S., left periotic; No. 4356, C. A. S., right periotic; No. 11865, U. S. N. M., right periotic; No. 4438, C. A. S., incomplete left radius; No. 4388, C. A. S., proximal end of right ulna; No. 4436, C. A. S., proximal end of left ulna; No. 4442, C. A. S., incomplete sternum; No. 4373, C. A. S., incomplete left scapula; No. 4374, C. A. S., neck of right scapula; No. 4375, C. A. S., neck of right scapula; No. 4443, C. A. S., neck of right scapula; Nos. 4390, 4391, 4393, C. A. S., phalanges; Nos. 4376, 4378, C. A. S., humeri.

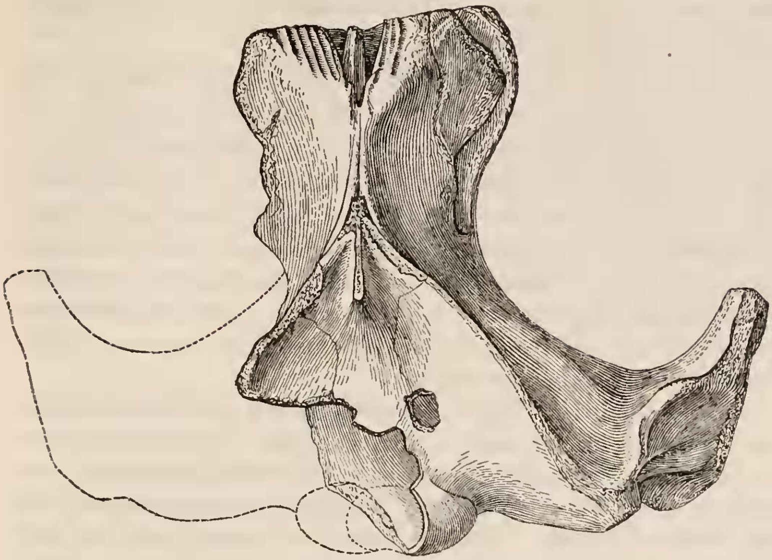
SKULL

In so far as the skull is concerned, this genus differs from *Plesiocetopsis* not only in the matter of the proportions of its component parts, such as wider temporal fossæ and a shortened antero-posterior diameter of the squamoso-exoccipital region between the level of the bulla and the zygomatic process, but also in having a more externally placed *foramen ovale* and the extremity of the alisphenoid reduced in the outer wall of the braincase in the temporal fossa.

In general form this braincase appears to be intermediate in some respects between *Plesiocetopsis occidentalis* (Kellogg)[42] and *"Idiocetus" longifrons* Van Beneden.[43] Of all the Belgian Miocene cetotheres, for which skulls are known, *"Idiocetus" longifrons* seems to exhibit the closest resemblance to the Temblor cetothere in the general conformation of the braincase. This upper Miocene species, however, exhibits no close relationship to the genotype, *Idiocetus guicciardinii,* from the upper Pliocene of Italy. The correct generic allocation of *"Idiocetus" longifrons* is somewhat doubtful and may be held in abeyance until a general revision of related species is attempted. The parietals of this skull meet in the intertemporal region to form a short sagittal crest, overspread the frontals in the interorbital region, and extend forward con-

[42] R. Kellogg, Publ. 348, Carnegie Inst. Washington, 1925, pp. 50-56, text figs. 7-10.

[43] P. J. Van Beneden, Ann. Mus. Roy. d'Hist. Nat. Belgique, vol. 13, 1886, pp. 72-76, pl. 65; pl. 66, fig. 1; pl. 67, fig. 1; pl. 68, figs. 1-3.



74

Fig. 74. Dorsal view of incomplete skull of *Tiphyocetus temblorensis*, No. 4355, C. A. S., × 0.25.

siderably beyond the level of the posterior margins of the supraorbital processes. The frontals are narrowly exposed in the interorbital region between the anterior extremities of the parietals and the posterior extremities of the nasals, premaxillæ, and maxillæ. The anterior temporal crests, which in some species mark the anterior limits of the areas from which the temporal muscles arise, are either weak or absent entirely. When the skull is viewed from above the curvature of the posterior margin of the squamosal, the depression of the surface adjoining the zygomatic process, and the relative anteroposterior diameter of the body of the squamosal appear to agree with the corresponding portion of the Temblor skull, but the curvature of the anterior margin of the squamosal in the temporal fossa is quite different. On the basis of the illustrations which accompany Van Beneden's memoir it would appear also that the skull of *"Idiocetus" longifrons* differs from that of the Temblor cetothere in that the supraoccipital shield has a more constricted apex, the vertical carina is longer, the extero-inferior angle of the postglenoid process is acute and

not rounded, and the lateral protuberances of the basioccipital are ovoidal and not elongated.

Dorsal view: The differential features of the Temblor skull are found in the architecture of the braincase (fig. 74). In contrast to the skull of *Plesiocetopsis megalophysum* (Cope), the extremity of the alisphenoid is reduced to a very small and narrow surface, the *foramen ovale* is placed nearer to the temporal edge of the squamosal, the temporal fossa as viewed from above is somewhat wider, the squamosal is shortened antero-posteriorly between the level of the bulla and the zygomatic process, and the width of the skull across the exoccipitals and zygomatic processes is greater.

Four skulls of a Calvert Miocene species of *Parietobalæna*, not designated at present by name because of our imperfect knowledge of a previously described cetothere from the same formation in Maryland, were available for comparison with the Temblor skull. They represent a species with a skull almost twice the dimensions of *Parietobalæna palmeri*. This cetothere had a wide temporal fossa, a broad basicranium, a squamosal shortened antero-posteriorly between the level of the bulla and the zygomatic process, a *foramen ovale* placed very close to the temporal margin of the squamosal, a basioccipital with wing-like descending processes, and exoccipitals with very thin extremities. It differs from the Temblor cetothere in having a different type of periotic, a basioccipital with wing-like processes instead of elongated lateral protuberances, a wider interval between the internal margins of the lateral processes of the basioccipital, slender, incurved zygomatic processes, an exoccipital with a much thinner extremity which is produced far below the level of the condyles, and much smaller condyles. The curvature of the postglenoid processes, on the other hand, is quite similar to that on the Temblor skull.

The loss of the orbital portions of the supraorbital processes of the frontals of the Temblor skull prevents detailed comparisons with some well known species, for their shape and direction, in addition to the contour of the temporal fossa, enable one to distinguish some species at a glance. At the base, each supraorbital process slopes gradually downward and outward from the median line of the post-narial region,

but, in case of the living whalebone whales. these processes are abruptly depressed at the base. The frontals are excluded from the vertex of the intertemporal region, and their posterior borders are overspread by thin plates of the parietals, although the latter terminate behind the level of the sutures which mark the position of the nasals and the ascending processes of the maxillæ and premaxillæ. These sutures also show that the basal portions of the nasal bones, as well as the ascending processes of the maxillæ and premaxillæ, were situated posterior to the rostral margin of the supraorbital processes. There is an emargination on each frontal for the reception of a nasal bone. The size and contour of the area occupied by the paired nasals shows that each of these bones was attenuated posteriorly.

The parietals come in contact with each other on the vertex of the intertemporal region between the apex of the supraoccipital shield and the frontals, and are suturally united with the supraoccipital bone posteriorly and the squamosal inferiorly. The sagittal crest is not as sharply defined on the type skull as on two other vertices referred to this species.

Compared with *Plesiocetopsis megalophysum,* the supraoccipital shield of the Temblor skull is broader at the base and not quite so high. The lateral or lambdoid crests of the triangular supraoccipital shield are well developed. There is a well defined carina on the apical portion of this shield, on either side of which the surface is slightly depressed. The condyles project beyond the level of the exoccipitals. The squamosals and their zygomatic processes form the posterior and outer margins of the temporal fossæ. The extremity of the right zygomatic process is missing and the external surface is eroded. The lambdoid crest is continuous inferiorly with a crest that curves forward and outward on the posterior margin of the squamosal. As in *Plesiocetopsis megalophysum,* the squamosal is strongly excavated below this carina.

The fragments of the maxillæ associated with this cranium do not exhibit any unusual peculiarities.

Posterior view: From this aspect, the supraoccipital shield is seen to curve forward and upward; it is somewhat depressed in the center below the median carina on the apex. The exoccipitals are relatively small, coalesce with the supraoccipi-

tal above, and project outward and backward. Each exoccipital is suturally united in front with the corresponding squamosal, and inferiorly it is fused with the basioccipital. The shape of the *foramen magnum* appears to be similar to that of *Plesiocetopsis megalophysum,* judging from the curvature of the internal margin of the right condyle. This condyle, however, is quite different in general shape from that of the last mentioned cetothere. It is considerably narrower at the apex than at the base, convex from side to side and end to end, and is set off from the exoccipital by a shallow excavation.

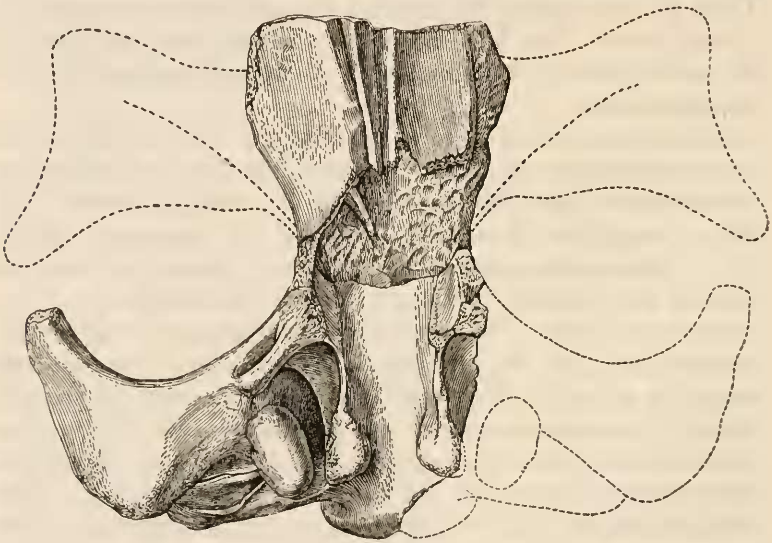
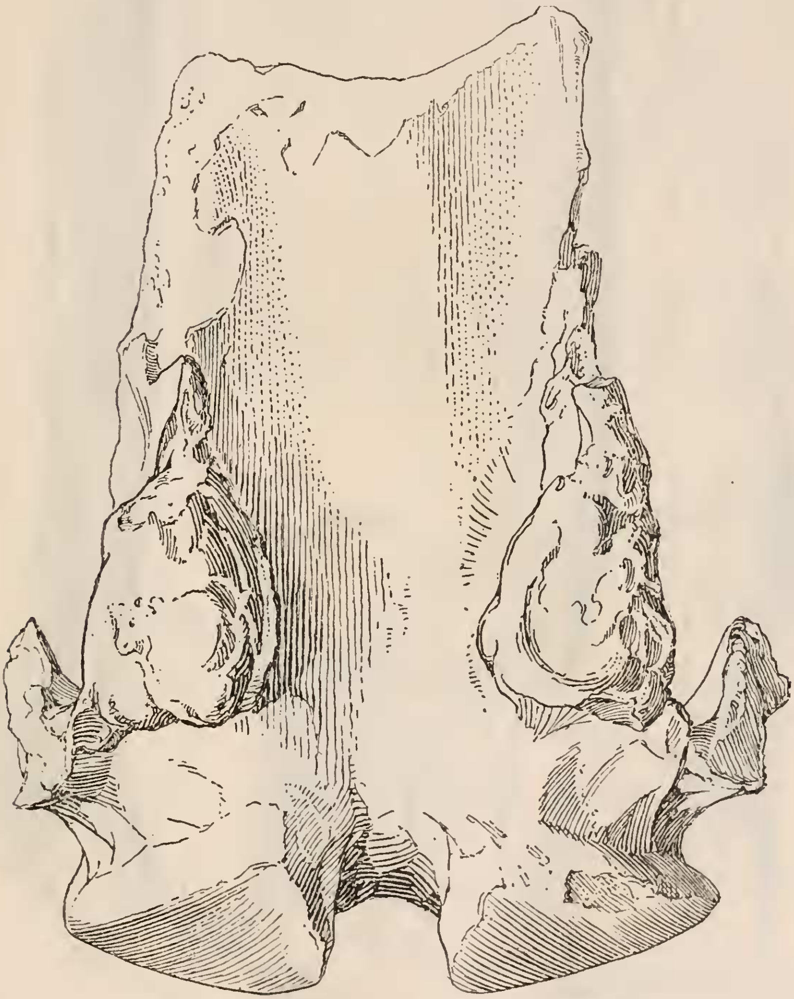


Fig. 75. Ventral view of incomplete skull of *Tiphyocetus temblorensis,* No. 4355, C. A. S., × 0.25.

Ventral view: The median region of the basicranium (fig. 75), which is concave from side to side, is formed as usual by the basioccipital and basisphenoid. The posterior horizontally expanded plate of the vomer, which overspreads the basisphenoid, is destroyed on both specimens. The anterior margin of the basisphenoid is concave and it is separated from the presphenoid by an open transverse suture. Portions of the pterygoids remain attached to the lateral margins of the basisphenoid on the type skull, but their posterior extensions are

destroyed. The latter contribute the internal walls of the pterygoid fossæ and abut against the lateral protuberances of the basioccipital. These lateral protuberances are relatively smaller than those on the skull of *Plesiocetopsis occidentalis*. When complete, these pterygoid bones bound the median



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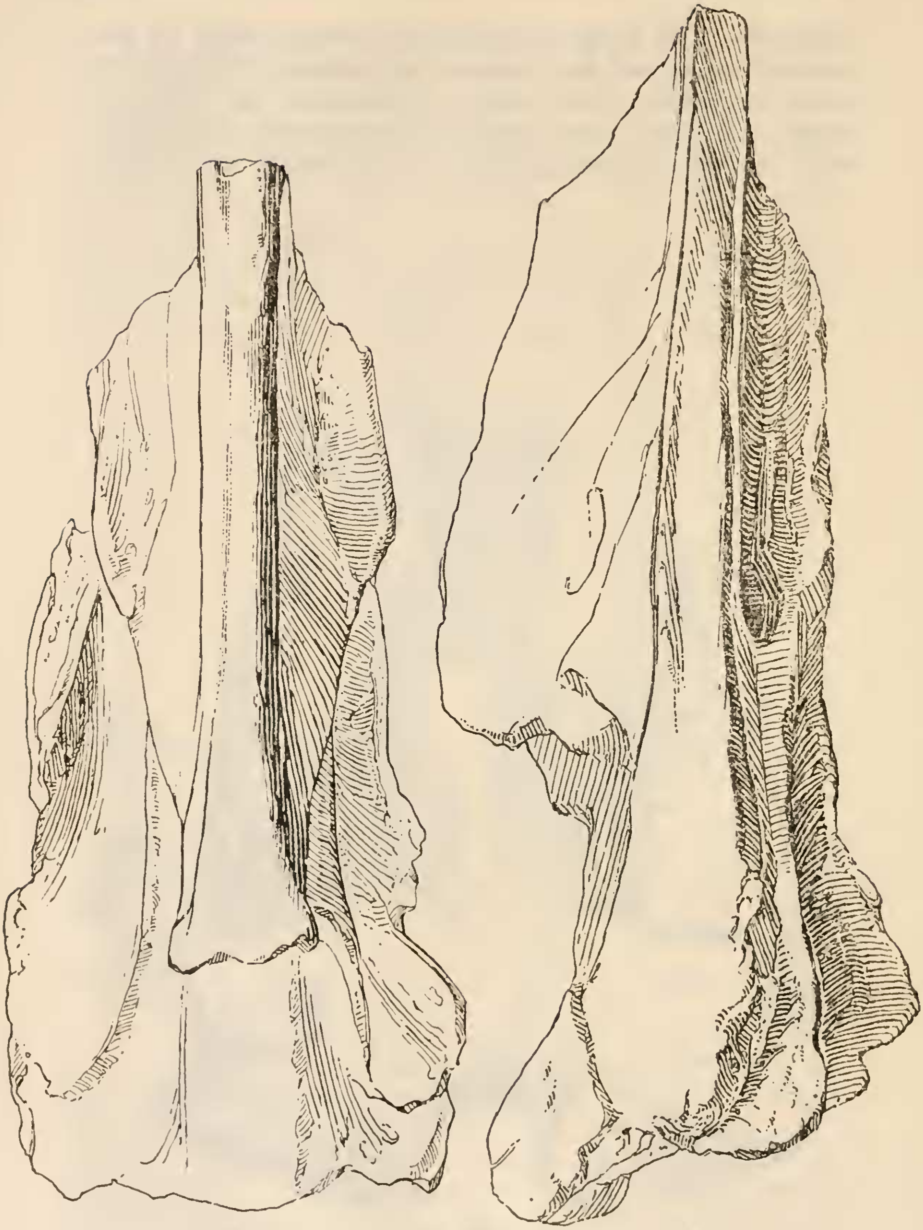
Fragment of skull of *Tiphyocetus temblorensis*, No. 4357, C. A. S., × 0.5. Fig. 76. Ventral view of basicranium.



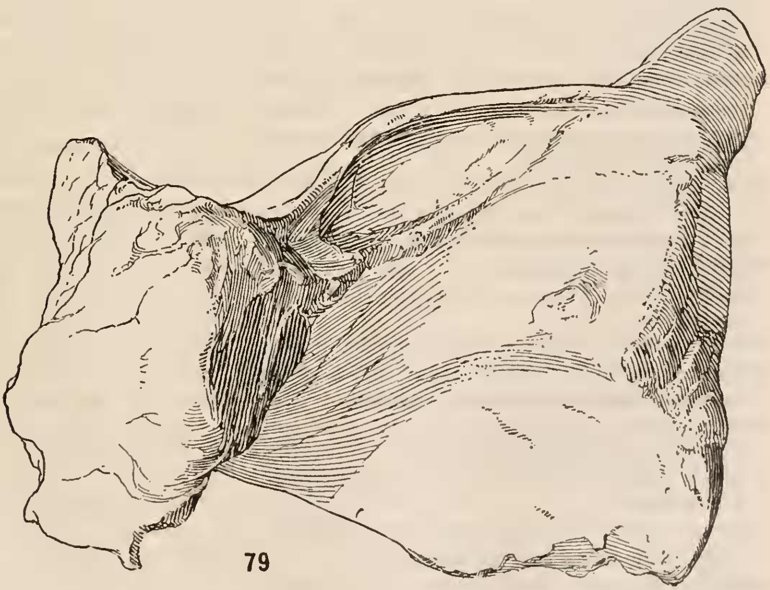
77 78

Fragments of skull of *Tiphyocetus temblorensis,* No. 4357, C. A. S., × 0.5. Fig. 77. Ventral view of vomer and presphenoid. Fig. 78. Proximal fragment of left maxillary.

region of the basicranium and take part in the formation of the lower borders of the choanæ.

On the type skull, the right pterygoid is in contact with the supraorbital process of the frontal, meeting the descending wall of the optic canal near its orifice. The alisphenoid is hidden by the pterygoid, and its extremity is reduced to a narrow strip in the temporal fossa. The roof of the pterygoid fossa is formed by the pterygoid. Behind this fossa is the large tympano-periotic recess. This recess is bounded by the squamosal externally, the exoccipital posteriorly, the basioccipital internally, and by the alisphenoid and overlying pterygoid anteriorly. In the temporal fossa, the pterygoid is suturally united with the frontal and squamosal, and anteriorly it forms the posterior wall of the optic canal.

The outer projection or zygomatic process of the squamosal is rather slender and flattened on its internal and external faces; the antero-internal portion of the squamosal is bifurcated to provide an orifice for the large *foramen ovale*. The narrow lower branch or falciform process is suturally united



79

Fragment of skull of *Tiphyocetus temblorensis*, No. 4357, C. A. S., × 0.5. Fig. 79. Posterior view of right exoccipital.

with the pterygoid on the outer wall of the pterygoid fossa. The broad upper portion is likewise sutured with the pterygoid. The curvature of the anterior or temporal margin of the squamosal is most pronounced in front of the glenoid region and corresponds in this respect to the skull of *Plesiocetopsis megalophysum*. Behind the falciform process there is a distinct emargination for lodging the anterior process of the periotic. The glenoid articular surface is rather wide and is concave antero-posteriorly. Behind this broad and rather

Measurements of Skulls (in millimeters)

	No. 4355, C. A. S.	No. 4357, C. A. S.
Greatest breadth of skull across zygomatic processes, estimated	636.0	....
Distance across skull between outside margins of exoccipitals, estimated	430.0	....
Vertical height of skull (basisphenoid to apex of supraoccipital)	185.0	....
Apex of supraoccipital shield to extero-inferior angle of exoccipital	335.+	....
Outside margin of extremity of zygomatic process to apex of supraoccipital shield	362.0	....
Antero-inferior margin of *foramen magnum* to apex of supraoccipital shield	273.0	....
Antero-inferior margin of *foramen magnum* to notch between frontals at base of nasals	360.0	....
Least breadth of cranium between temporal fossæ	162.0	....
Breadth of *foramen magnum*	....	57.0
Greatest distance between outer margins of occipital condyles	....	161.5
Greatest vertical diameter of right condyle	103.0	94.0
Distance from antero-inferior margin of *foramen magnum* to anterior margin of basisphenoid	200.0	202.0
Greatest distance across basioccipital between outside margins of lateral protuberances	123.0	148.0
Greatest depth of vomerine trough at anterior end of presphenoid	....	127.5
Distance between tip of postglenoid process and tip of zygomatic process of right squamosal	199.5[1]	228.5[1]
Apex of supraoccipital shield to notch between frontals at base of nasals	115.0	....

[1] As preserved.

robust postglenoid process is a wide shallow channel for the external auditory meatus which commences at the postero-internal angle of the squamosal and curves outward. The apophysis or posterior process of the periotic is wedged in between the posterior face of the squamosal and the flattened exoccipital. The narrowing of the inferior edge of the exoccipital resulted in a corresponding decrease in the area available for the attachment of neck muscles. The posterior or lacerated foramen is continuous externally with the tympano-periotic recess and is continued backward across the exoccipital as a broad groove between the poorly defined paroccipital process and the corresponding lateral protuberance of the basioccipital.

Periotic

The periotic of this cetothere exhibits a surprisingly close resemblance to those of the St. Marys *Plesiocetopsis megalophysum* (Cope), and the Scaldisian (middle Pliocene) *Balænula balænopsis*.[44] The periotics of these fossil whales exhibit the same side to side compression of the anterior process, but the periotic of *Balænula balænopsis* is distinguished by its larger size, by the greater antero-posterior diameter of the *pars cochlearis* and a larger cerebral orifice for the aqueduct of the cochlea. The bullæ of both of these fossil whales are compressed from side to side and have a median longitudinal ventral ridge. It would probably be difficult, if not impossible today, to explain the association of the periotic figured by Van Beneden with the other skeletal remains of *Balænula balænopsis*. This right periotic lacks the posterior process, but the body is not much larger than that of the Temblor cetothere. As a whole this Belgian periotic is quite unlike any known member of the family Balænidæ and the writer is inclined to suspect that it does not belong to *balænopsis*. In so far as it is possible to make comparisons with the periotic of *Plesiocetopsis megalophysum*, it is practically identical with that of the Temblor cetothere.

In the Antwerp Basin during the Miocene and early Pliocene there were at least three other species of fossil whales

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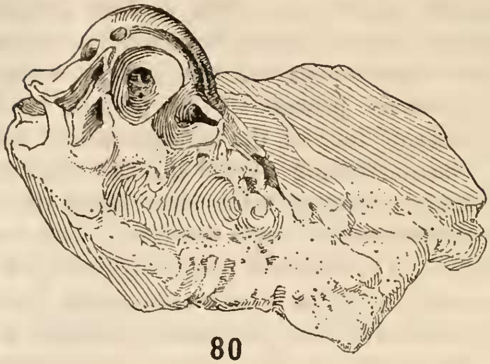
[44] P. J. Van Beneden, Ann. Mus. Roy. d'Hist. Nat. Belgique, vol. 4, pl. 3, figs. 25-26, 1878.



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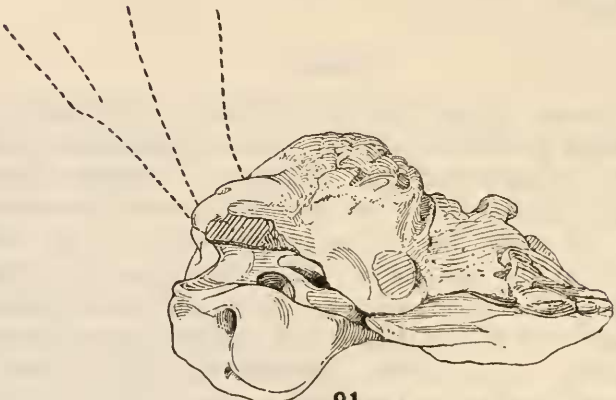

81

Incomplete right periotic of *Tiphyocetus temblorensis*, No. 4353, C. A S., × 1.0. Fig. 80. Cerebral view. Fig. 81. Inferior view.

with periotics similar to those of the Temblor cetothere, but the bullæ referred to these species are quite different. The periotic of the Diestian (lower Pliocene) *"Idiocetus" longifrons*[45] has a posterior process that closely resembles the corresponding process of the Temblor periotic, and the relative size and position of the aqueducts of the cochlea and vestibule also agree, but a comparison of the cerebral views shows that the body of the former is deeper and more rounded, the anterior process is shorter, and there are differences in the relative positions of the entrance to the *aquæductus Fallopii* and the internal acoustic meatus. It is desirable to point out

[45] P. J. Van Beneden, *op. cit.*, pt. 5, vol. 13, 1886, pl. 67, figs. 2, 3, 4.

here that the periotic of the genotype, *Idiocetus guicciardinii,*[46] which belongs to the Astian (middle Pliocene) fauna of Italy, is so unlike the Belgian species that one might infer that the periotic of the latter either is erroneously associated with the other skeletal remains or else the generic allocation is incorrect. The periotic of the Diestian *Amphicetus later*[47] has an exceedingly long and slender posterior process, a rather large *pars cochlearis,* and the cerebral orifice of the *aquæductus vestibuli* opens into a groove. The periotic of the Diestien (lower Pliocene) *Plesiocetopsis hupschii*[48] has a much larger body, the outline of the combined anterior process and the body being distinctly triangular, and the cerebral orifice of the *aquæductus cochleæ* is larger, but the posterior process is not unlike that of the Temblor cetothere. The periotic (figs. 80, 81) of the Temblor cetothere possesses features which allocate the species in the group of small whalebone whales allied to *Plesiocetopsis hupschii.* The limits and diagnostic criteria for this group are rather indefinite at present and are likely to remain so until all known material is critically studied. It is unfortunate that so little attention was given to accurate methods of curatorial procedure at the time the specimens from the basin were passing through the hands of Du Bus, Van Beneden, their artists, and assistants.

Portions of four periotics belonging to at least three different individuals are the basis for the following diognosis. The posterior process (fig. 75) is elongate, attenuated at both ends, and relatively narrow. It is wedged between the exoccipital and the squamosal, while the body and the *pars cochlearis* project into the large recess behind the pterygoid fossa. The posterior pedicle of the bulla is fused with the posterior process on the proximal end of the ridge which follows the anterior border. Behind this ridge is the deep groove which marks the position of the facial nerve on its outward course. The external denser portion or body of the periotic is compressed from side to side, and its depth is fully one-fourth greater than its width. The external surface of the body is strongly convex and the internal surface is irregularly

[46] G. Capellini, Balene Fossili Toscane, III. Idiocetus Guicciardinii. Mem. R. Accad. Sci. Bologna, (6), 1905, vol. 2, pl. 1, figs. 2, 3, 4.

[47] P. J. Van Beneden, *op. cit.,* pt. 5, vol. 13, 1886, pl. 1, figs. 1, 2, 3.

[48] P. J. Van Beneden, *op. cit.,* pt. 4, vol. 9, 1885, pl. 21, figs. 2-7.

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excavated. The external surfaces of the body and anterior process are relatively smooth on two of these periotics, but are strongly rugose on the third. The *pars cochlearis* is small and not quite twice as long as broad; the ventral surface is convex and the external surface rises almost vertically from the inner margin of the *fenestra ovalis*. The internal outline of the *pars cochlearis* of the periotic here figured (fig. 80), viewed from the ventral side, is more strongly arched than on a second periotic (No. 11865, U. S. N. M.). The posterior face of the periotic is abruptly truncated above the circular *fenestra rotunda*. The *fenestra ovalis* is partially encircled by a very narrow rim and is sunk below the level of the channel for the facial nerve. A carina more distinct on one (No. 11865, U. S. N. M.), than on another (No. 4353, C. A. S.) separates the channel for the facial nerve from the *fenestra ovalis*. Small orifices of the semicircular canals can be seen at the bottom and on the outer wall of the vestibule. On one of these periotics (No. 11865, U. S. N. M.) there is a deep and narrow groove leading forward from the external rim of the *fenestra ovalis* to the notch between the *pars cochlearis* and the anterior process. This groove is much less distinct on the periotic here figured and does not extend backward beyond the level of the anterior pedicle of the bulla. The fossa for the stapedial muscle is broader than long and extends downward upon the internal face of the posterior process and the external face of the *pars cochlearis*.

Bordering on the external margin of the epitympanic orifice of the *aquæductus Fallopii* (fig. 81) is a large shallow concavity for lodging the head of the malleus. The exact limits of this articular surface are not sharply defined and it appears to be continuous externally with the depression on the outer denser portion of the periotic. In front of this facet is the base of the slender anterior pedicle which supports the bulla. The *fossa incudis* appears to have been destroyed on all of these periotics. The anterior process is compressed from side to side and rather deep; the extremity is emarginate on the periotic here figured and is straight on the others.

Some of the most important features of this periotic are found on the cerebral face. Below the apex of the *pars cochlearis* is the internal accoustic meatus, at the bottom of

which is the spiral tract and a minute *foramen singulare*. Because of its oblique position and the funnel-like shape of the meatus, the *tractus spiralis foraminosus* is largely hidden from a cerebral view. A high thick transverse crest separates the large entrance to the aqueduct of Fallopius from the more centrally placed internal acoustic meatus. Posterior to the meatus is the small orifice of the aqueduct of the cochlea and above the latter is the large deep fossa into which the aqueduct of the vestibule opens. Between this fossa and the entrance to the aqueduct of Fallopius is a rather prominent projection. A large excavation is present on the cerebral face of the body above the entrance to the aqueduct of Fallopius. There is a broad deep groove on the posterior face, bordered on each side by distinct crests, which commences at the posterior margin of the stapedial fossa and extends to the cerebral angle. The smooth convex surface of the *pars cochlearis* does not extend as far as the rim of the internal acoustic meatus and the irregular margin thus formed accentuates the jagged appearance of the cerebral face.

Measurements of Periotics (in millimeters)

	No. 11865, U.S.N.M. Right	No. 4353, C. A. S. Right	No. 4354, C. A. S. Left	No. 4356, C. A. S. Right
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	31.3	31.2	....	34.4
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	28.4	33.5	....	28.0
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	([1])	50.0	51.0	40.5

[1]Extremity of anterior process missing.

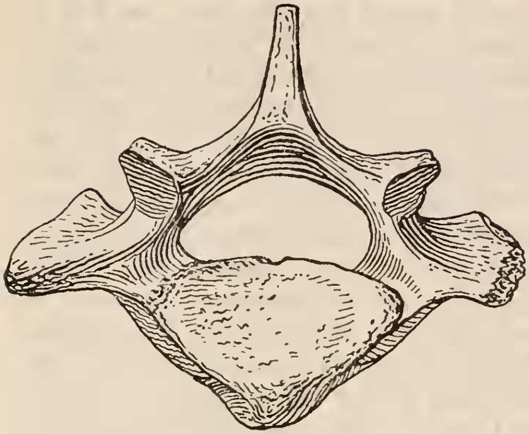
Bulla

The right tympanic bulla (fig. 75) attached to the skull is complete, and is characterized by the narrowness of the posterior end. The involuted portion of the bulla is depressed below the level of the overarching, thin, outer lip and decreases in thickness anteriorly. The dorsal surface of the involucrum is transversely creased and exhibits the usual convex undulation.

The anterior pedicle is rather slender, and the posterior pedicle in cross section would appear "V"-shaped, with the apex behind. A narrow groove separates the posterior conical apophysis from the sigmoid process, and, in front of the latter, the thin outer lip is traversed in a vertical direction by a rather broad groove. The ventral profile shows that the bulla is depressed mesially. The ventral and external faces of the bulla form a continuous curved surface, but a fairly sharp angular crest separates the ventral and internal faces. The posterior end of the bulla is strongly attenuated. In contrast to the bulla of *Plesiocetopsis megalophysum,* where the eustachian angle corresponds to the antero-internal angle, the eustachian angle of the bulla of the Temblor cetothere is placed mesially on the anterior border. The greatest length of this bulla is 87.8 mm., and that of the bulla of *Plesiocetopsis megalophysum* is 94 mm. The bulla of the Calvert Miocene cetothere is considerably smaller, measuring less than 65 mm. in length. The greatest width of the Temblor bulla is 48.7 mm. and its depth at the level of the posterior apophysis is 52 mm.

Scapula

It is not improbable that the differences observed in the four incomplete scapulæ (Nos. 4373, 4374, 4375, and 4443, C. A. S.) referred to this species are due to individual variation. One (No. 4373, C. A. S.) of these is sufficiently complete to show the size and proportions of its component parts. The fan shaped blade (fig. 85) is rather high, with a regularly convex vertebral margin and an essentially straight posterior margin above the neck. The prescapular fossa is certainly very much reduced and may have been limited to the rather



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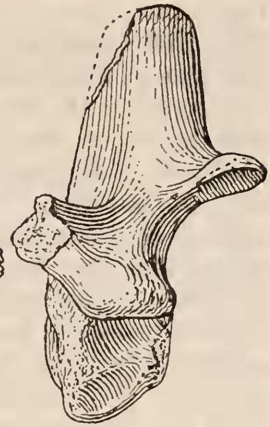
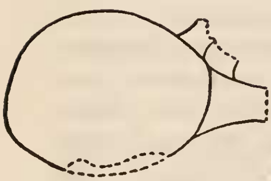


83

Cervical vertebra of (?) *Tiphyocetus temblorensis,* No. 4400, C. A. S., about × 0.5. Fig. 82. Posterior view. Fig. 83. Lateral view.



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85

Scapulæ of *Tiphyocetus temblorensis,* × 0.5. Fig. 84. Distal view of right scapula, No. 4375, C. A. S. Fig. 85. External view of left scapula, No. 4373, C. A. S.

broad anterior face. The young of some species of recent finback whales have a scapula shaped like this fossil one, but in older individuals the vertebral margin is much less convex. The base of the acromion process is quite broad, but its length is uncertain. On this scapula most of the coracoid process is missing, but on one of the others (No. 4375, C. A. S.) the basal half of the long attenuated coracoid process, which arises close to the margin of the glenoid cavity is retained, and it is directed obliquely inward and downward. The glenoid articular surface (fig. 84) on one of these scapulæ (No. 4375, C. A. S.) is considerably expanded, the maximum diameters in the two directions being 101 mm. and 80 mm. The glenoid surface of the best preserved scapula measures 98 mm. and 66 mm. The greatest depth of the left scapula (No. 4373, C. A. S.) is about 240 mm., and the greatest width is estimated to be about 330 mm. It is difficult to make proper allowances for age without having a large series for comparison, and, for the present, all four of these scapulæ may be referred tentatively to this species.

Fore Limb

The remaining parts of the fore limbs of the Temblor cetothere are not readily distinguishable from those of a number of Pliocene and Miocene cetotheres found elsewhere. In case of living whalebone whales, age differences are reflected in the bones of the fore limb, and limb bones without definite data are allocated correctly only with considerable difficulty. A corresponding amount of age and individual variation may be expected in these fossil cetotheres. The forearm of the Temblor cetothere is considerably longer than the humerus, and the ulna is longer than the radius. No carpal bones were noted, but a number of phalanges of various sizes which belong either to this species or to one of the other cetotheres hereinafter described were sorted out for comparison. The largest of these phalanges (No. 4390, C. A. S.) has a maximum length of 81 mm. and a width of 56 mm. The smallest (No. 4393, C. A. S.) measures 57.5 mm. by 42.5 mm. There is nothing peculiar about any of these phalanges as they are all expanded transversely at their extremities and flattened in a dorso-plantar direction.

Humerus

The general shape of the humerus of this cetothere is quite similar to the right humerus referred by Van Beneden[49] to *Amphicetus rotundus.* The head and tuberosities on the proximal end of the left humerus (No. 4376, C. A. S.) are eroded away, but the right humerus (No. 4378) is fairly well preserved, with the exception of the greater tuberosity. The humerus of this cetothere has a large globular head and a prominent greater tuberosity, but the lesser tuberosity is not as distinct as on a Calvert Miocene cetothere humerus. The large head is not set off from the shaft by a well marked neck, and the groove between it and the greater tuberosity is rather broad. Below this grove on the outer face of the humerus is a shallow and slightly roughened area for the infraspinatus muscle. The lower portion of the shaft is rather broad and is flattened in an extero-internal direction. The distal end is divided into two articular surfaces divided by a median crest. The upper surfaces of the radius and ulna are applied to these facets. The posterior profile of the humerus is strongly convex. A low protuberance on the antero-external angle of the shaft below the greater tuberosity modifies the anterior profile. The humerus of the Calvert Miocene cetothere has a large elongated fossa on the posterior face of the shaft about 18 mm. above the ulna face, but the Temblor humeri lack this fossa. It is possible that this fossa may mark the origin of one of the divisions of the triceps muscle, possibly the short head.

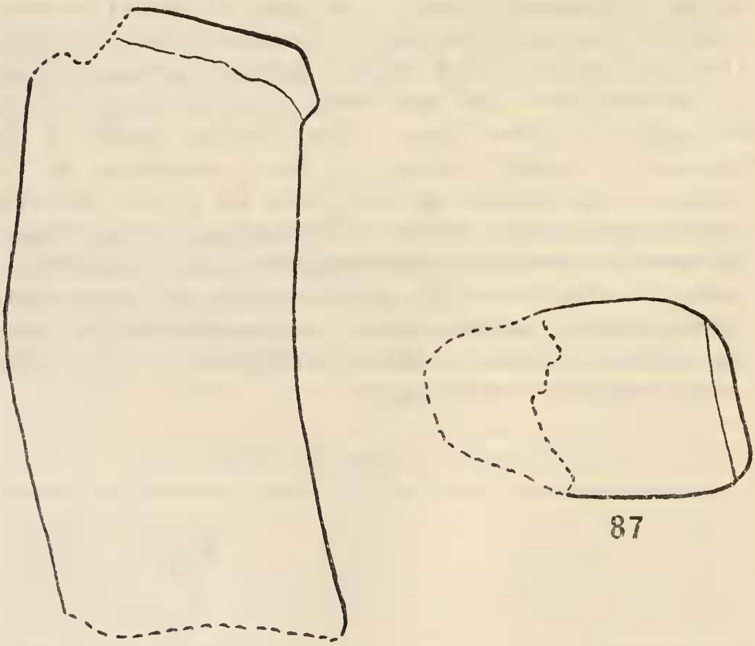
Measurements of Humeri (in millimeters)

	No. 4376, C. A. S. Left	No. 4378, C. A. S. Right
Greatest length	208.+	243.8
Extero-internal diameter of distal end	60.5	61.0
Antero-posterior diameter of distal end	104.0	109.5
Greatest diameter of head	....	96.0

[49] P. J. Van Beneden, Ann. Mus. Roy. d'Hist. Nat. Belgique, vol. 13, 1886, pl. 17, figs. 4, 5.

Radius

The left radius (fig. 86) referred to this cetothere lacks the distal extremity. As is usual with these cetaceans, it has a rather simple form, and its curvature conforms to that of the shaft of the ulna. The shaft of the radius averages wider than that of the ulna. The external and internal surfaces of the shaft are convex, forming crest-like anterior and posterior margins. The maximum antero-posterior diameter of the shaft is 69.5 mm. and the maximum extero-internal diameter is 41.5 mm. The facet (fig. 87) on the proximal end for articulation with the humerus is flattened. There is also a well defined ulnar facet.



86 87

Incomplete left radius of *Tiphyocetus temblorensis*, No. 4438, C. A. S., × 0.5. Fig. 86. Internal view of shaft. Fig. 87. Proximal view.

Ulna

The proximal end of a right ulna (No. 4388, C. A. S.), and the proximal and distal ends of a left ulna (No. 4436, C. A. S.) are ascribed to this species. Their articular surfaces and proportions agree with the humeri described above. In general proportions, the shaft of the ulna (fig. 88) is not quite as slender as that of *Heterocetus affinis*.[50] Both of these cetotheres have a well developed olecranon process projecting backward from the shaft of the ulna. The lower portion of the greater sigmoid cavity is considerably broader than the upper, and the articular surface of the former extends over upon the external face. The facet for the radius is broad and rather deep. The distal end of the shaft is expanded in an antero-posterior direction and flattened from side to side. The total length of the ulna when complete is estimated to be about 375

88

Fig. 88. Internal view of right ulna of *Tiphyocetus temblorensis*, No. 4388, C. A. S., × 0.5.

[50] P. J. Van Beneden, Ann. Mus. Roy. d'Hist. Nat. Belgique, vol. 13, 1886, pl. 24, fig. 3.

mm.; the greatest diameter of the distal end is 87 mm., and the maximum extero-internal diameter of the lower portion of the greater sigmoid cavity is 46.5 mm.

Sternum

In view of the extraordinary variation which may be observed in sterna of recent whalebone whales, one should not attribute much importance to differences in general shape of these bones. True[51] has figured 25 sterna of *Balænoptera physalus,* many of which have quite unusual shapes. One or two bear a general resemblance to the sternum referred to the Temblor cetothere, particularly True's text figure 14. The sternum (No. 4442, C. A. S.) of the Temblor cetothere is wider than long, with rather broad posterior arm or stem. The right wing of the broad anterior portion was broken off and no contact can be found between two pieces included in the collection. Nevertheless this sternum appears to have had the anterior border entire, with a medial vacuity or perforation below it, and with the wings scarcely differentiated. The greatest length of this sternum is 178 mm.; the greatest width (estimated), 225 mm.; and the maximum transverse diameter of the stem, 66 mm.

9. **Peripolocetus vexillifer**[52] Kellogg, new genus and species

Holotype: No. 4370, Mus. Calif. Acad. Sci. from **Sharktooth Hill, Kern County, Calif.**; Temblor, Miocene; Charles Morrice, Coll., 1924. Consists of the squamosal region on the right side, the corresponding portion of exoccipital, periotic and bulla, right occipital condyle, and a portion of basioccipital.

Referred specimens: No. 4358, right humerus; Nos. 4387, 4389, C. A. S., proximal end distal ends of left ulnæ.

Skull

The cranial fragments show that this cetothere had a considerably larger skull than *Tiphyocetus temblorensis.* The

[51] F. W. True, The whalebone whales of the western North Atlantic. Smithson. Contrib. to Knowledge, vol. 33, publ. 1414, 1904, pp. 140-141, text figs. 8-32.

[52] Περιπολος, a patrol; κητος, whale.

external margin of the extremity of the exoccipital is rounded and relatively thin. The ventral surface of this bone behind the cochlear portion of the periotic is rather thick, affording a considerable surface for muscle attachment. The combined zygomatic and postglenoid portions of the squamosal are produced much farther outward beyond the extremity of the exoccipital than in *Tiphyocetus temblorensis*. Unfortunately the ventro-external angle of the postglenoid process and the extremity of the zygomatic process are missing, but the general shape is quite similar to that of *Tiphyocetus*. On the other hand, the ventral surface of the squamosal between the level of the bulla and the postglenoid process is very strongly convex, in contrast to the corresponding concave surface on the *Tiphyocetus* skull, and the curvature of the temporal margin of *Peripolocetus* is decidedly more convex. It would appear from the material at hand that this skull had a narrower temporal fossa than exhibited by *Tiphyocetus*.

Viewed from behind, the curvature of the posterior margin of the squamosal is similar to that of *Tiphyocetus*, but the lambdoid crest rises more abruptly and the braincase swells out more noticeably above the level of the anterior process of the periotic. The right condyle is rather large, concave from end to end and from side to side, but is not borne on a distinct neck. It measures 107.5 mm. in length and has a maximum width of 59 mm. The inferior end is bluntly rounded and the superior end is pointed. It attains its maximum width at a point about half way between the middle and the superior end. Only a portion of the lateral protuberance on the right side of the basioccipital is preserved, but it is enough to show that it was relatively large.

Periotic

The ventral portion of the cochlear region of the right periotic, including the area occupied by the *fenestra rotunda* and aqueduct of the cochlea, is missing, but otherwise this bone is quite complete. The long posterior process with the expanded extremity is wedged as usual between the exoccipital and the squamosal. The body of the periotic is characterized chiefly by the large, swollen, anterior process which gives a characteristic shape to the whole bone. The *foramen ovale* and

epitympanic orifice of the *aquæductus Fallopii* are located at about the same level, and the groove for the passage of the facial nerve posteriorly is limited to the internal surface of the posterior process.

The large stapedial fossa is deep, sub-elliptical in outline, and is shut off from the broad and rather deep transverse trough on the posterior face of the periotic by a thin raised margin. The spiral tract and the entrance to the aqueduct of Fallopius are placed within a common ovoidal meatus, and the transverse bony crest which separates the *aquæductus Fallopii* from the fossa occupied by the spiral tract does not rise half way to the level of the cerebral rim of the internal acoustic meatus. The *foramen singulare* is placed at the bottom and within the fossa occupied by the *tractus spiralis forminosus*. The spiral tract is strongly coiled and ends in a distinct *foramen centrale*. There appears to be a distinct *area vestibularis inferior*. The surface in the area occupied by the fossa for lodging the head of the malleus is very rugose and the margins of this fossa are very poorly defined. The *fossa incudis* consists of a small irregular concavity located on a thin, inwardly projecting ledge. The large swollen anterior process differs from that of *Tiphyocetus*, not only in its large size, but also in that it is turned inward almost at right angles to the body of the periotic, and its direction is parallel to that of the anterior process.

Bulla

The left tympanic bulla associated with the cranial fragments appears rather small for so large a skull and may not have belonged to this species. The heavy involucrum is creased transversely, concavo-convex from the rear forward, and gradually decreases in thickness anterior to the level of the sigmoid process. The tympanic cavity which is bounded by the thin over-arching outer lip is rather narrow posteriorly, but widens at the level of the anterior pedicle, and then diminishes as it approaches the eustachian angle.

The involucrum and the outer lip contribute the two sides of the V-shaped posterior process. The posterior apophysis is small and blunt, and is separated from the sigmoid process by a short crease. The sigmoid process is missing. Between the

sigmoid process and the anterior pedicle the outer lip of the bulla is deeply grooved. Viewed from the external side, the ventral profile is slightly convex, and gradually merges with the strongly convex posterior profile. There is a distinct angle between the anterior and ventral profiles. The smooth convex ventral surface of the bulla passes into the internal and external surfaces without any perceptible change in curvature, although an irregular crease marks the ventral limits of the involucrum. A fairly distinct longitudinal crest traverses the ventral surface at the anterior end; the posterior end is somewhat flattened. The greatest length of this bulla is 89.3 mm.; greatest width, 45.5 mm.; greatest depth at level of posterior apophysis, 60 mm.; and the width of involucrum at level of anterior margin of posterior process is 40 mm.

Humerus

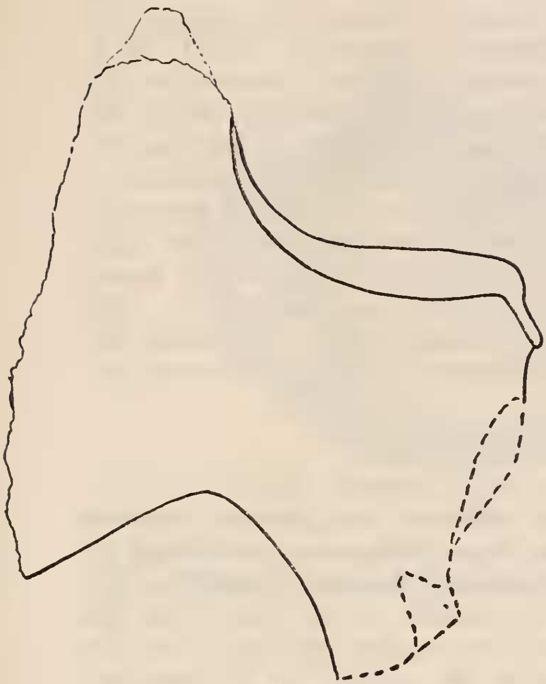
This right humerus (fig. 89) is very well preserved and is somewhat larger than those referred to *Tiphyocetus temblorensis*. The large globular head is set off from the shaft by a distinct neck and on the external face is separated from the greater tuberosity by a broad groove. A large, rounded protuberance placed mesially on the proximal end of the humerus is identified as the lesser tuberosity. The small rugose area, which marks the origin of one of the divisions of the triceps muscle—possibly the short head—is placed near the posterior border of the outer face of the shaft and this area is nearer to the head than to the ulnar facet. The facets on the distal end of the humerus which articulate with the radius and ulna are similar in shape to those on the humerus of *Tiphyocetus,* although the humerus of the latter has a somewhat broader ulnar facet. The measurements of the right humerus in millimeters are as follows: greatest length, 274.5; extero-internal diameter of distal end, 121; antero-posterior diameter of distal end, 63; and greatest diameter of head, 107.

Ulna

Proximal and distal ends of somewhat larger left ulnæ (Nos. 4387, 4389, C. A. S.) than those referred to *Tiphyocetus temblorensis* may belong to this cetothere. The ole-

89

Fig. 89. Right humerus of *Peripolocetus vexillifer*, No. 4358, C. A. S., × 0.5



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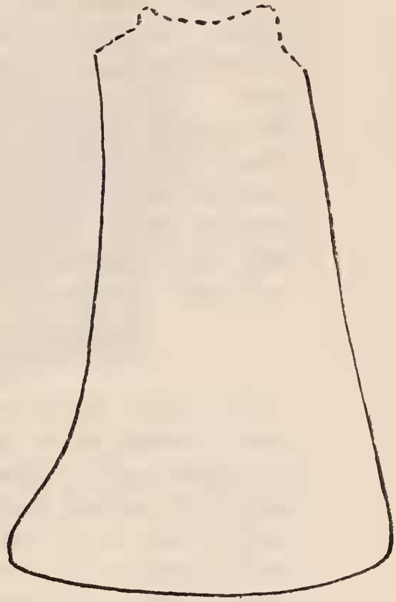


91

Fragments of ulnæ of (?) *Peripolocetus vexillifer,* × 0.5. Fig. 90. Internal view of proximal end of left ulna, No. 4389, C. A. S. Fig. 91. Distal end of left ulna, No. 4387, C. A. S.

cranon process (fig. 90) is quite large, and the upper portion of the sigmoid cavity forms an obtuse angle with the lower horizontal articular surface. The radial facet is rather deep and is convex from side to side. The external face of the shaft is convex and the internal flattened. Most of the distal expansion (fig. 91) is due to the enlargement of the posterior angle.

10. **Parietobalæna (?) securis** Kellogg, new species

Holotype: Left periotic, without posterior process, No. 4371, Mus. Calif. Acad. Sci. from **Sharktooth Hill, Kern County, California**; Temblor, Miocene; Charles Morrice, Coll., 1924.

Referred specimens: Posterior process of left periotic, No. 4579, C. A. S.; and incomplete braincase, No. 4372, C. A. S.

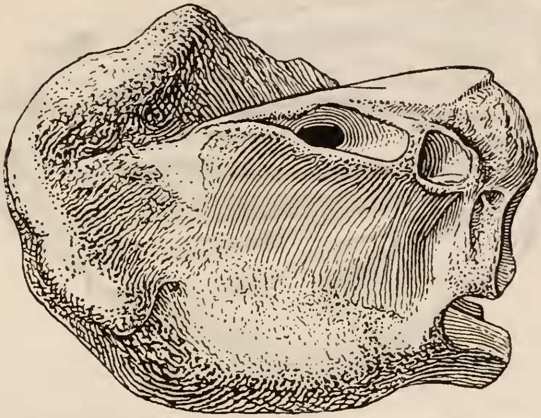
A badly eroded and damaged braincase is referred to this species. The general aspect of the cranium is similar to that of *Parietobalæna palmeri,* but it is slightly larger than the latter. The entire supraoccipital shield, with the exception of the apex, is destroyed. The right exoccipital is preserved. The right postglenoid process is complete though the zygomatic process is missing. Although both condyles are imperfect, the right is more nearly complete than the left. The small lateral descending processes of the basioccipital are knob-like. The precise conformation of this skull is unknown.

Periotic

Aside from having a much narrower groove or dorsoventral excavation on the posterior face above the stapedial fossa, this periotic differs from *Tiphyocetus temblorensis* in having the cerebral face noticeably flattened, a somewhat different profile of the *pars cochlearis,* when viewed from the cerebral side, and a considerably shorter anterior process. In these respects it approaches the periotic of *Parietobalæna palmeri*[53] and until the skull of *securis* is found, it is tentatively allocated to the genus *Parietobalæna.*

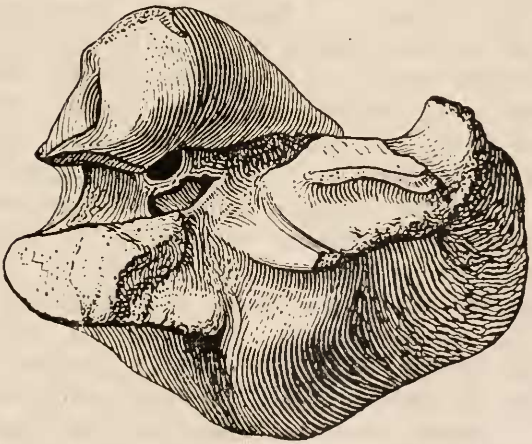
When contrasted with the periotics of *Tiphyocetus temblorensis,* the left periotic of *securis* is seen to have a much thicker body and anterior process, and a more convex external surface. In the region of the anterior pedicle of the bulla, the extero-inferior margin of the anterior process is produced outward, forming a crest which projects beyond the external face. In these respects this periotic (fig. 93) bears a striking resemblance to those of *Parietobalæna.* The *pars cochlearis* is larger than in *Tiphyocetus,* but it is not so strongly inflated in the region of the *fenestra rotunda* as in the latter. The *fenestra rotunda* is large and produces a well marked indentation on the posterior profile. The large elliptical *fenestra ovalis* is encircled by a narrow rim, which is set off from the stapedial fossa and the channel for the facial nerve by a rather broad osseous crest. The rim of the *fenestra ovalis* is not sunk below the level of the channel for the facial nerve as on

[53] R. Kellogg, Proc. U. S. Nat. Mus., vol. 63, publ. 2483, 1925, pp. 9-11, pl. 5.



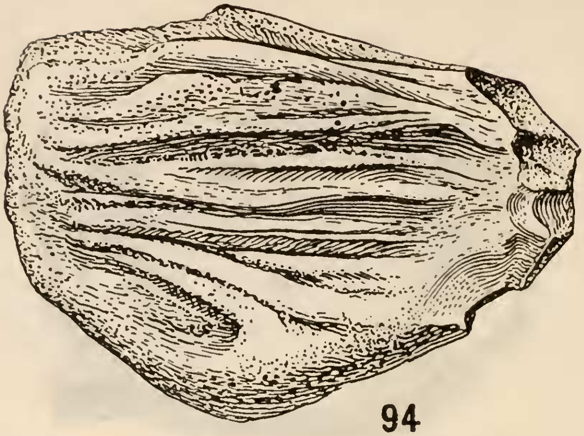
92

Fig. 92. Cerebral view of incomplete left periotic of *Parietobalæna (?) securis*, No. 4371, (C. A. S.), × 1.0.



93

Fig. 93. Inferior view of incomplete left periotic of *Parietobalæna (?) securis*, No. 4371, (C. A. S.), × 1.0.



94

Fig. 94. Posterior process of left periotic of *Parietobalæna (?) securis*, No. 4579, (C. A. S.).

the periotic of *Tiphyocetus,* and the interval between the internal face of the *pars cochlearis* and the *fossa incudis* is somewhat wider. Small orifices for the superior and posterior semicircular canals are located at the bottom and on the outer wall of the vestibule. A break, which fortunately passed through the vestibule, enabled the writer to trace the course of the semicircular canals and it was observed that they did not differ from those of recent whales. One structure was exposed which was heretofore unknown to the writer. Within the substance of the body of the periotic and posterior to the vestibule is a blind aqueduct, which communicates with the portion of the *pars cochlearis* traversed by the cochlear duct, and, because of its position with reference to the periotic cistern and the semicircular canals, it is considered to house the *sacculus endolymphaticus*. This duct was not found in the periotics of the recent *Berardius* and *Tursiops,* or in several species of fossil porpoises. It may possibly be present, however, in recent whalebone whales, but the writer did not have periotics of these whales which could be sectioned to determine the point. The fossa for lodging the head of the malleus is placed in front of the epitympanic orifice of the aqueduct of Fallopius between the *pars cochlearis* and the anterior process, and not wholly on the anterior process as in *Tiphyocetus*.

The channel for the facial nerve (fig. 93), which curves backward from the epitympanic orifice of the aqueduct of Fallopius, is not set off from the fossa for the stapedial muscle by a carina and is largely concealed by the inwardly projecting border of the posterior process. The fossa for the stapedial muscle is broad and quite deep, and terminates posteriorly at the emargination resulting from the development of a rather deep dorso-ventral groove on the posterior face. Between the stapedial fossa and the *fenestra rotunda*, a sharp edged crest is developed on the posterior extension of the *pars cochlearis* which contributes the internal face for the groove on the posterior surface. The poorly defined *fossa incudis* is placed opposite the epitympanic orifice of the aqueduct of Fallopius and at the apex of the excavation on the ventral surface of the outer denser portion of the periotic. The anterior process is foreshortened, and, in consequence of the curvature of the external face its extremity, is directed inward.

Although the arrangement and position of the various structures on the cerebral face (fig. 92) are approximately the same, the general appearance of this surface is quite unlike that of *Tiphyocetus temblorensis*, but it does correspond in all essential details with that of *Parietobalæna*. The cerebral profile of the *pars cochlearis* is quite characteristic, being oblique and nearly straight in front, convex internally, and with a median projection posteriorly. The rim of the deep internal acoustic meatus is raised above the surrounding surface and is placed some distance away from the entrance to the *aquæductus Fallopii*. This meatus is somewhat narrower at the bottom than at the rim. At the bottom and on the dorsal wall of this meatus is the rather large *foramen singulare*. The spiral tract is short and strongly curved. The groove or trough, which extends from the anterior rim of the internal acoustic meatus to the entrance of the aqueduct of Fallopius, is a remnant of the former course of the aqueduct and shows that the facial nerve has shifted forward in consequence of the general flattening of the cerebral face, thereby shortening the aqueduct which passes through the substance of the periotic on the anterior border of the *pars cochlearis*. Behind the rim of the internal acoustic meatus is the minute orifice of the aqueduct of the cochlea, and above it is an elongate fossa into which

the aqueduct of the vestibule formerly opened, but which in this particular pariotic is entirely closed.

A posterior process of a left periotic (No. 4579, C. A. S.), which bears a close resemblance to that of *Parietobalæna palmeri,* is referred to this species. This short swollen process is somewhat flattened on its anterior face and strongly convex posteriorly.

Measurements of the Periotic

Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	47.3 mm.
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	25.5 mm.
Distance between epitympanic orifice of the *aquæductus Fallopii* and tip of anterior process	39.6 mm.

Suborder Odontoceti: Toothed Whales

The discovery of the skull of the large physeterid, *Aulophyseter morricei,* was one of the most important finds made by Mr. Morrice in his excavations on Sharktooth Hill. This physeterid may have been fairly numerous in the Temblor seas, for periotic bones of at least nine individuals were found by the collector. The finding of a single periotic bone that apparently belongs to some squalodont is another interesting but not unexpected discovery. Prior to the field work carried on by Mr. Morrice, remains of squalodonts were unknown in the North Pacific region, although their occurrence in Tertiary formations of New Zealand, Australia, and Tasmania has been known for many years. This find, if confirmed by the discovery of a determinable skull, will extend the geographic range of squalodonts to include most of the Miocene seas. Numerous discoveries in the north and south Atlantic regions bear witness to their presence elsewhere in the Miocene period.

Quite a variety of smaller porpoises frequented the Temblor seas in association with the archaic whalebone whales and the somewhat larger sperm whale. The cranial peculiarities of these porpoises are as yet unknown to us. On the basis of the

periotic bones it has been possible to distinguish at least nine species of porpoises. Vertebræ and limb bones of some of these are included in the collection, but their relation to any particular porpoise is too uncertain to warrant any specific allocation. The apparent absence of the long-snouted porpoises, which are so characteristic of the Miocene formations in the Atlantic region, is quite puzzling. None of these periotics agree with those of the long-snouted porpoises, *Eurhinodelphis* and *Cyrtodelphis*. At least one, *Eurhinodelphis pacificus*,[54] of the long-snouted porpoises has been recognized by Matsumoto in the Miocene Shiiya formation of Japan. Their occurrence in the Temblor fauna is to be expected. The periotics hereinafter described are types commonly associated with skulls of short-snouted porpoises.

Humerus

Six humeri of odontocetes were found in the collection, but it is obviously impossible to allocate any of them to any particular porpoise hereinafter described. They form a part of our record of the Temblor pelagic fauna and are worthy of mention.

95

Fig. 95. External or lateral view of large left humerus of an odontocete, No. 4361, C. A. S. × 0.5.

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[54] H. Matsumoto, Sci. Reports Tôhoku Imp. Univ., ser. 2, Geol., vol. 10, no. 1, 1926, pp. 21-23, fig. 3; pl. 9, figs. 1-4.

The largest (fig. 95) of these humeri is about the same size as that of *Eurhinodelphis bossi.* This humerus is damaged, with portions of the anterior and posterior surfaces of the distal end missing, and with the inner surface of the tuberosity eroded. The broadly oval head is not set off from the shaft by a distinct neck. The infraspinous fossa of the humerus is rather broad. Below this fossa is a well marked swelling.

96 97

Right humerus of an odontocete, No. 4363, C. A. S., × 0.5. Fig. 96. Internal or medial view. Fig. 97. External or lateral view.

A somewhat smaller right humerus (figs. 96-97) possesses a peculiar process on the posterior angle of the distal extremity. This process seems to be the proximal end of the olecranon process which has fused with the humerus. When viewed from the front, the internal face curves from the distal end to the tuberosity, but the external face is nearly straight. The large deep infraspinous fossa is placed below the head and on the anterior half of the shaft. The circular head does not have a distinct neck and is placed at about the same level as the tuberosity. There is a conspicuous indentation on the anterior border of the distal end of the shaft and a transverse crest separates the trochlea for the radius from that for the ulna. The process on the posterior angle of the distal end is rather thin and is set off from the trochlea for the ulna by a narrow groove. In the region of the insertion of the masto-humeralis and the origin of the triceps muscles on the proximal end of the shaft are two small prominences.

The third humerus (figs. 98-99) has a somewhat stouter shaft than the preceding. The circular head is placed con-

98

99

Right humerus of an odontocete. No. 4362, C. A. S., × 0.5. Fig. 98. External or lateral view. Fig. 99. Internal or medial view.

siderably below the level of the tuberosity and projects very little beyond the shaft. On the anterior border of the head is a rather broad groove that extends inward to the tuberosity. The deep infraspinous fossa comes in contact with the inferior margin of the head and is placed near the center of the shaft. The swelling on the anterior face of the shaft above the distal end presumably marks the insertion of the deltoid muscle. The trochlea for the radius and that for the ulna are separated by a complete mesial transverse crest.

100

Fig. 100. External or lateral view of left humerus of an odontocete. No. 4364, C. A. S., × 0.5.

The upper end of the shaft of this left humerus (fig. 100) is eroded. The head is slightly lower than the tuberosity and there is no distinct neck. Furthermore, the deep infraspinous fossa does not meet the lower margin of the head as on the humerus just described, but it does have a prominent swelling on the anterior face. The transverse crest separating the

trochlea for the radius from that for the ulna is not complete. The curvature of the outer and inner surfaces of the shaft are similar to that of the third humerus.

There are, in addition, two slender badly worn humeri of some small odontocete. These humeri have a shallow infraspinous fossa and a low transverse crest separating the trochlea for the radius from that for the ulna. The ulna trochlea extends upward upon the posterior face of the distal extremity.

Measurements of Humeri (in millimeters)

	No. 4361, C. A. S. Left	No. 4362, C. A. S. Right	No. 4363, C. A. S. Left	No. 4364, C. A. S. Right
Greatest length (greater tuberosity to distal margin)	103.0	65.5	72.5	66.0
Extero-internal diameter of shaft at level of lower margin of infraspinous fossa	31.5	20.0	20.5	19.5
Antero-posterior diameter of distal end of shaft	....	33.7	40.0	32.5
Extero-internal diameter of proximal end of humerus	55.+	40.0	42.8	41.5

Ulna

Two fairly complete ulnæ and the proximal ends of four others are referred to odontocetes. All of these ulnæ are smaller and shorter than those of cetotheres.

The largest (fig. 101) of these ulnæ is short, broad, and compressed. It is quite broad at the distal end and is narrowest below the facet for articulation with the radius. From its free posterior border, near the proximal end, rises the compressed olecranon process which unfortunately is largely destroyed. The sigmoid cavity for the humerus is slightly curved and its surface is eroded. This ulna belongs to a rather large odontocete, while all of the periotic bones hereinafter described are unquestionably those of porpoises of small and medium size. Judging from its shape, it would appear

101

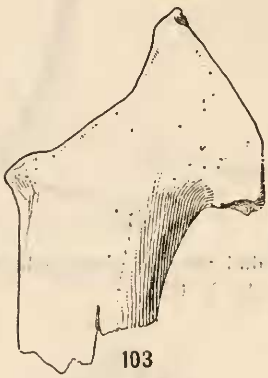
Fig. 101. Internal or medial view of large right ulna of an odontocete, No. 4365, C. A. S., × 0.5.

102

Fig. 102. Internal or medial view of right ulna of an odontocete. No. 4366, C. A. S., × 0.5.

that this ulna might possibly belong to a young individual of *Aulophyseter morricei.*

The ulna here figured (fig. 102) has a rather slender shaft. It is compressed from side to side and is expanded at the distal end. It is considerably larger than the same bone of the recent *Tursiops truncatus.* The facet for articulation with the head of the radius projects considerably beyond the anterior face of the shaft. The proximal end of the thin, compressed olecranon process is missing. With the exception of the proximal border, the sigmoid cavity for articulation with the humerus is nearly straight.

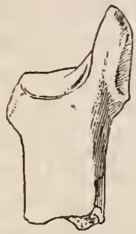


103

Fig. 103. External or lateral view of left ulna of an odontocete. No. 4437, C. A. S., × 0.5.

The proximal end of a left ulna (fig. 103) of about the same proportions as that of *Squalodon* has a fairly complete olecranon process. The shaft is convex externally and flat internally. It lacks a distinct fact for articulation with the radius and the broad sigmoid cavity is subvertical on its proximal third. This ulna is tentatively referred to *Squalodon errabundus.*

This ulna (fig. 104) lacks the distal end of the shaft. In size it corresponds rather closely with that of the recent *Tursiops truncatus.* It differs from the latter, however, in having a less flattened shaft and in the entire absence of a groove on the internal face below the sigmoid cavity. The olecranon process is rather narrow and ends in a proximal



104

Fig. 104. External or lateral view of left ulna of an odontocete. No. 4368, C. A. S., × 0.5.

pointed tip. The sigmoid cavity is broad and strongly curved, with a side to side curvature. It has a large facet for articulation with the radius.

A small left ulna (fig. 105) likewise lacks the distal half of the shaft, but possesses the upper end of the olecranon process. It differs from the following ulna (No. 4367, C. A. S.) in having a trace of a groove on the internal face below the sigmoid cavity. The facet for articulation with the radius is

105

Fig. 105. External or lateral view of left ulna of small odontocete. No. 4435, C. A. S., × 0.5.

broad and quite rugose. The sigmoid cavity is raised along the median line and the narrow proximal half is turned almost at right angles to the broad distal half. The shaft is elliptical in cross section.

The corresponding portion of another small left ulna is characterized by having a narrower sigmoid cavity than the preceding, a greatly reduced olecranon process, a groove on the internal face below the radial facet, and a markedly flattened shaft.

The proximal end of another small left ulna (No. 4367, C. A. S.) corresponds fairly well in the curvature of the lower end of the olecranon process, in the curvature of the sigmoid cavity, and in the proportions of the shaft with the corresponding bone of *Delphinodon dividum*.[55] It is barely possible that this ulna may belong to *Œdotus mirus*, the porpoise hereinafter described from a periotic bone, for the periotic resembles that of *Delphinodon dividum* in some respects.

Measurements of Ulnæ (in millimeters)

	No. 4365, C. A. S. Right	No. 4366, C. A. S. Right	No. 4437, C. A. S. Left	No. 4368, C. A. S. Left	No. 4435, C. A. S. Left	No. 4367, C. A. S. Left
Length, proximal end sigmoid cavity to distal end	153.0	116.0	....	....	....	....
Breadth at proximal end	62.+	54.5	69.0	34.0	26.0	31.0
Breadth at distal end	81.7	49.0	....	....	....	....
Least antero-posterior diameter of shaft	42.0	25.7	48.0	20.0	16.0	18.5
Length of olecranon	....	....	58.4	29.5+	23.+	....

Phalanges

Several flattened phalanges which probably belong to odontocetes were sorted out of the collection made by Mr. Morrice. Two of them have a distinctly hour-glass outline. The largest of these (No. 4394, C. A. S.) measures 45 mm. in length, 35 mm. in width at the base, and the least diameter is 19 mm. The other phalanx (No. 4567, C. A. S.) is 35 mm. long and 26.5 mm. wide at the base. A third phalanx (No. 4564, C. A. S.) is very slightly constricted, and it measures 55 mm. in length and 31 mm. in width at the base. The other phalanges are broken and worn, and present no special peculiarities.

[55] F. W. True, Description of a new fossil porpoise of the genus *Delphinodon* from the Miocene formation of Maryland. Journ. Acad. Nat. Sci. Philadelphia, (2), vol. 15, 1912, p. 184, pl. 25, fig. 4.

Vertebræ

Quite a number of odontocete vertebræ were collected by Mr. Morrice, but most of them are imperfect. The neural spines, transverse processes, and, in many cases, the neural arches as well are either damaged or missing.

One series of 15 vertebræ consists of two dorsals (Nos. 4495, 4496, C. A. S.), one lumbar (No. 4497, C. A. S.), and twelve caudals (Nos. 4498 to 4509, C. A. S.). These vertebræ are considerably smaller than the corresponding vertebræ of *Priscodelphinus atropius*, and the centra are relatively longer. The dorsal vertebræ have the centra strongly constricted near the middle and the dorsal margins of both epiphyses are nearly straight. The largest dorsal (No. 4496, C. A. S.) measures 56 mm. in length and the height of the centrum posteriorly is 35 mm. The lumbar vertebra (No. 4497, C. A. S.) has broad transverse processes and an indistinct longitudinal keel on the inferior face. It is 68.5 mm. long and the height of the posterior face of the centrum is 41 mm. The five anterior caudals (Nos. 4498 to 4502, C. A. S.) have the transverse processes pierced basally by a foramen. Their neural canals are narrow and high, and progressively diminish in height. Large descending processes for articulation with the chevron bones are developed on the inferior surface at the posterior end of the centrum. The largest of these caudals (No. 4499, C. A. S.) measures 55.5 mm. in length, and the greatest height of the centrum posteriorly is 40.5 mm. Two smaller caudals (Nos. 4503 and 4504, C. A. S.) retain vestiges of the neural arches and possess a pair of longitudinal plate-like descending processes on the inferior surface of the centrum, but lack transverse processes. Five terminal caudals (Nos. 4505 to 4509, C. A. S.), varying in length from 28.5 mm. to 25.5 mm., lack a neural canal. The centrum of each of these caudals is pierced dorso-ventrally by paired vertebrarterial canals that open inferiorly into a deep longitudinal groove.

Another series of five vertebræ (Nos. 4530, 4531, 4546, 4532, 4533, C. A. S.) have rather slender centra. This series includes four lumbars and one caudal. All of the lumbars have a prominent longitudinal inferior carina, on each side of which is a broad diagonal groove that extends from the

middle of the centrum to the posterior basal angle of the transverse process. Although none of these vertebræ has a complete neural arch, there is sufficient evidence to show that the neural canal was very narrow. The neural arches and transverse processes approximate the anterior margins of the centra. The single caudal vertebra (No. 4533, C. A. S.) has rather high neural arches, a low neural spine, and a very small neural canal. The transverse processes are largely destroyed, but were pierced basally by a foramen. The ventral surface of the centrum is eroded. The largest lumbar (No. 4546, C. A. S.) measures 58.2 mm. in length.

Fifteen caudal vertebræ (Nos. 4510 to 4522, 4527, 4528, C. A. S.) are thought to represent still another type of porpoise. These caudals do not represent a continuous series and may have belonged to several individuals. The largest caudal (No. 4511, C. A. S.) measures 59 mm. in length and the smallest (No. 4522, C. A. S.) 25 mm. The larger caudals have their transverse processes pierced at the base by a foramen. They possess large descending processes for the chevrons and have narrow neural canals. The caudals near the posterior end of the series have very low neural arches, the neural canal is nearly closed, and the neural spine is very low. With one exception, all of these caudals lack vestiges of the transverse processes. These caudals possess a pair of longitudinal plate-like descending processes on the inferior surface of the centrum. The three small terminal caudals (Nos. 4520 to 4522, C. A. S.) have a pair of thick longitudinal ridges on the inferior surface of the centrum.

Four badly eroded lumbar vertebræ (Nos. 4523 to 4526, C. A. S.) differ from those heretofore described in having more robust centra, although the largest of these vertebræ hardly measured more than 65 mm. in length when complete.

Among the remaining miscellaneous vertebræ are six which belong to a much smaller porpoise than any of those heretofore mentioned. A small dorsal vertebra (No. 4534, C. A. S.), about 30 mm. in length, has the centrum contricted mesially. It lacks all of its processes. A posterior dorsal (No. 4539, C. A. S.) referred to the same porpoise is likewise incomplete. It measures 43.5 mm. in length. On the four lumbars (Nos. 4538, 4537, 4536, and 4540, C. A. S.), the longitudinal

inferior carina progressively increases in depth. The length of the largest No. 4538, C. A. S.) of these lumbars is 48 mm. and the smallest (No. 4540, C. A. S.) is 41 mm. All of these vertebræ have rather slender centra.

A single small caudal vertebra (No. 4541, C. A. S.) has a high neural spine, small neural canal, and short transverse processes. The centrum has deep concavities above and below the transverse processes. It measures 35.5 mm. in length, and the distance from the tip of the neural spine to the inferior surface of the centrum is 51.5 mm.

Fragments of an atlas (No. 4543, C. A. S.), two axes (Nos. 4544, 4545, C. A. S.), and the centrum of a cervical vertebra (No. 4542, C. A. S.) belong to some small porpoise. In addition to the foregoing vertebræ, there is a rather large caudal vertebra (No. 4529, C. A. S.) which indicates the presence of a porpoise of about the same proportions as *Priscodelphinus atropius*.

Key to Periotic Bones of Porpoises From the Temblor Formation, Sharktooth Hill, Near Bakersfield, California

1. Extremity of anterior process resembles the handle-end of a crutch when viewed from in front; between the *fenestra ovalis* and the deep concave fossa for the head of the malleus is a narrow crescentric excavation which commences near the epitympanic orifice of the *aquæductus Fallopii* and extends downward upon the external face of the *pars cochlearis;* the large egg-like accessory ossicle is firmly ankylosed to the ventral face of the anterior process; postero-internal angle of ventral facet on posterior process, when complete, reaches to the level of internal margin of stapedial fossa; cerebral face of outer denser portion of periotic nodular; greatest antero-posterior diameter of *pars cochlearis* 20 mm. or more............*Aulophyseter morricei* (p. 361)

   Extremity of anterior process either pointed, rounded, or abruptly truncated; greatest antero-posterior diameter of *pars cochlearis* less than 20 mm.. 2

2. Extremity of anterior process (antero-ventral angle) attenuated and pointed.. 3

   Extremity of anterior process rounded, or abruptly truncated and compressed from side to side................................ 4

3. No incisure on posterior face above and internal to stapedial fossa; anterior process swollen; entrance to aqueduct of *Fallopius* constricted; cerebral and external faces of outer denser portion of periotic form a continuous smooth convex surface; internal acous-

tic meatus cucurbital in outline; transverse diameter, excluding posterior process, 24-26 mm.......... *Squalodon errabundus* (p. 373)

A deep incisure on posterior face above and internal to stapedial fossa; apical portion of anterior process on ventral face grooved longitudinally to support outer lip of bulla; groove for facial nerve sinks below level of external rim of *fenestra ovalis;* entrance to aqueduct of Fallopius constricted; transverse diameter, excluding posterior process, less than 21 mm....... *Liolithax kernensis* (p. 375)

4. A subtriangular flattened or depressed area on cerebral face behind internal acoustic meatus, the apex of which is occupied by the fossa inclosing the cerebral orifice of the aqueduct of the vestibule; a pit is usually present on the posterior face above the stapedial fossa.. 5

Not as in preceding, and with orifice of aqueduct of vestibule in closer proximity to rim of internal acoustic meatus............ 7

5. Anterior process with longitudinal carina on cerebral face; groove for facial nerve does not sink below level of external rim of *fenestra ovalis;* posterior face of posterior process concave above ventral facet; a low crest is present on antero-external border of ventral face of *pars cochlearis* opposite to the facet for the accessory ossicle.. 6

Anterior process without longitudinal carina on cerebral face; *pars cochlearis* strongly inflated posterior to aqueduct of cochlea; a deep pit on posterior face above stapedial fossa; stapedial fossa bounded internally by a thin-edged crest; a well defined crest is present on antero-external border of ventral face of *pars cochlearis* opposite to the facet for the accessory ossicle. *Œdolithax mira* (p. 378)

6. Triangular depressed area behind internal acoustic meatus sharply defined, with apex produced beyond fossa inclosing cerebral orifice of aqueduct of vestibule...... *Lamprolithax simulans* (p. 381)

Triangular depressed area behind internal acoustic meatus less sharply defined and with apex not produced beyond fossa inclosing cerebral orifice of aqueduct of vestibule. *Lamprolithax annectens* (p. 383)

7. Greatest diameter of periotic (tip of anterior process to apex of ventral facet on posterior process) more than 25 mm................. 8

Greatest diameter of periotic (tip of anterior process to apex of ventral facet on posterior process) less than 25 mm.; cerebral face of outer denser portion of periotic flattened; entrance to *aquæductus Fallopii* constricted; no pit is present on posterior face above stapedial fossa....................... *Nannolithax gracilis* (p. 386)

8. Cerebral face of outer denser portion of periotic broad, distinctly flattened and depressed external to internal acoustic meatus, and general plane of this surface forms a right angle with the external surface; a subconical swelling posterior to cerebral orifice of aqueduct of cochlea; no pit is present on posterior face above stapedial fossa; facial canal sinks below level of external rim of *fenestra ovalis*.................. *Platylithax robusta* (p. 388)

Cerebral face of outer denser portion of periotic convex, with the outer two-thirds more or less flattened...................... 9

9. Outline of internal face of anterior process as viewed from the cerebral side distinctly convex; posterior face of posterior process rounded or flattened above ventral articular facet 10
   Outline of internal face of anterior process as viewed from the cerebral side nearly straight; a pit on posterior face above stapedial fossa; posterior face of posterior process excavated and concave above ventral articular facet .... *Loxolithax sinuosa* (p. 390)
10. Antero-external border of ventral face of *pars cochlearis* traversed by a low crest; a pit or slit-like depression is present on posterior face above stapedial fossa .... *Grypolithax pavida* (p. 396)
   Antero-external border of ventral face of *pars cochlearis* smooth, without any trace of a crest; posterior face depressed above stapedial fossa, but no pit is present .... *Grypolithax obscura* (p. 393)

Family PHYSETERIDÆ: Sperm Whales

11. **Aulophyseter morricei** Kellogg[56]

Type specimen: No. 11230, Division of Vertebrate Paleontology, U. S. Nat. Mus. The type consists of a skull in a fair state of preservation. The supraorbital process of the left frontal and overlying maxilla, the left lachrymal and jugal, and the extremity of the rostrum are missing. Four enamel-crowned teeth and a right periotic were found near this skull.

Paratype: Portions of the skull (No. 11313, U. S. N. M.) of a young whale or embryo were found about 20 feet from that of the adult.

Referred specimens: Right periotic, No. 10853, U. S. N. M.; right periotic, No. 2794, C. A. S.; right periotic, No. 2795, C. A. S.; left periotic, No. 2796, C. A. S.; right periotic, No. 2797, C. A. S.; right periotic, No. 2798, C. A. S.; left periotic, No. 2799, C. A. S.; right periotic, No. 2800, C. A. S.; right periotic, No. 2801, C. A. S.; (?) mandibular teeth, Nos. 2802, 2803, 2804, 2805, 2806, 4575, 4576, C. A. S.

The skull (fig. 106) is especially interesting, for it demonstrates that the reduction of the maxillary dentition had commenced as early as the Middle Miocene. The top of the skull has been adjusted to lodge a fat or spermaceti cushion, and, in correlation with this peculiar structure, the relative proportions and relations of the bones forming the dorsal surface have

[56] R. Kellogg, Study of the skull of a fossil sperm whale from the Temblor Miocene of southern California. Publ. 346, Carnegie Inst. Washington, 1927, pp. 1-23, pl. 1-9.

January 30, 1931

been altered to form a large supracranial basin. The dorsal cranial elements are markedly asymmetrical and the left narial passage is much larger than the right.

Skull

About four feet in length; distal constriction of rostrum coextensive with the shallow, closely approximated, alveolar grooves; no trace of distinct or vestigial alveoli for lodging teeth in the upper jaw; a large maxillary incisure and a smaller posterior maxillary foramen; more or less flattened, broad, premaxillaries forming the dorsal surface of median portion of rostrum and shallow supracranial basin; right premaxillary expanding behind narial passages into a broad thin plate which is applied to upper surface of frontal and overlaps the maxillary along its internal margin; left premaxillary turned out of its course by enlargement of the corresponding narial passage and apparently terminated near posterior margin of this passage; premaxillaries forming extremity of rostrum; maxillary relatively thick posterior to antorbital notch and forming lateral wall of supracranial basin; supracranial basin limited posteriorly by transverse crest of supraoccipital and continued laterally to elevated portion of maxillaries; postnarial portion of right maxillary not meeting the left in the middle line; left narial passage much larger than the right; tapering zygomatic processes placed rather far forward; short temporal fossa; parietal excluded from vertex of skull; two orifices for infraorbital system on ventral face of maxillary; lachrymal narrow, firmly lodged between maxillary and supraorbital process of frontal, and fused with broad jugal which does not project much more than half way across orbit; palatine bones large, broad, and not projecting forward beyond anterior margins of anterior infraorbital orifices; pterygoids with large hamular processes; falcate processes of basioccipital projecting beyond level of condyles; a deep jugular incisure; alisphenoid thin, large, expanded horizontally, bounded anteriorly by supraorbital process of frontal, suturally united posteriorly with squamosal, and in contact with anterior surface of exoccipital; no tympano-periotic recess; optic canal confluent with sphenoidal fissure; *foramen ovale* pierces basal portion of alisphenoid; large jugulo-acoustic canal.

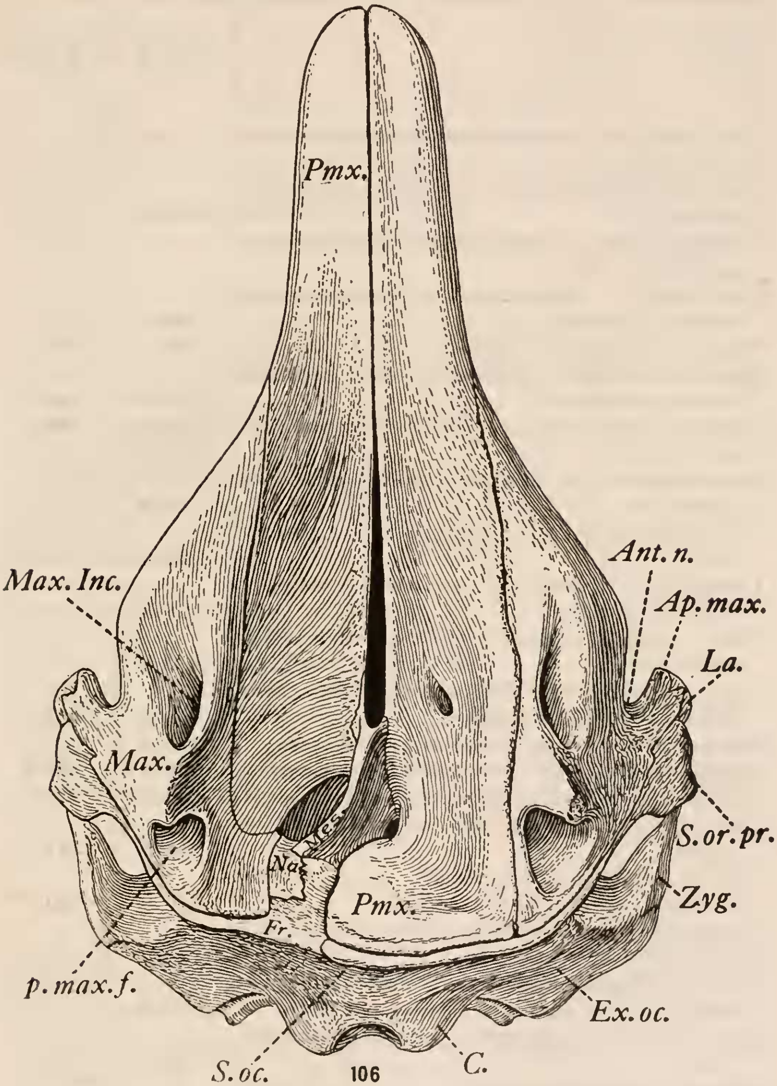


Fig. 106. Dorsal view of skull of *Aulophyseter morricei*, restored, No. 11230, U. S. N. M., × ⅛.

Measurements of Skull (in millimeters)

	No. 11230, U. S. N. M. Adult	No. 11313, U. S. N. M. Young
Total length, as preserved (condyles to tips of premaxillæ)	1114.0	....
Total length, as estimated (condyles to tips of premaxillæ)	1210.0	....
Length of rostrum, as preserved (antorbital notches to extremity)	712.0	....
Total length of rostrum, as estimated (antorbital notches to extremity)	800.0	....
Breadth of rostrum at antorbital notches, as restored	558.0[1]	354.0
Breadth of rostrum at swelling in front of antorbital notches, as restored	595.0[1]	360.0
Greatest breadth of skull across supraorbital processes, as restored	{725.0[2] 748.0[3]	490.0 ....
Greatest breadth of skull across zygomatic processes of squamosals	718.0	....
Vertical height of skull (basioccipital to transverse crest)	298.0+	....
Vertical height of skull (hamular process of pterygoid to transverse crest)	443.0+	....
Vertical height of rostrum at base (at level of antorbital notches)	177.0	....
Greatest width of right maxilla from a ventral view (inside margin to apophysis)	363.0	210.0
Greatest length of right premaxilla, as preserved	988.0	....
Greatest breadth of right premaxilla at level of nares	121.0	82.0
Greatest breadth of right premaxilla posterior to nares	197.0	....
Least breadth of right premaxilla in front of antorbital notches	113.0	74.+[4]
Greatest antero-posterior diameter of supraorbital process of right frontal at extremity	137.0	100.0[5]
Greatest thickness of preorbital portion of supraorbital process of right frontal	40.0	....
Elevation of lateral crest of supracranial basin above orbit	250.0	....
Least breadth of supraoccipital between temporal fossæ	480.0	....
Distance from summit of transverse crest to upper margin of *foramen magnum*	133.+	....
Height of *foramen magnum*	78.0	....
Breadth of *foramen magnum*	95.0	....

[1] Estimated. [2] Anteriorly. [3] Posteriorly. [4] Inner border missing. [5] Left.

Measurements of Skull (in millimeters)

	No. 11230, U. S. N. M. Adult	No. 11313, U. S. N. M. Young
Greatest distance between outside margins of occipital condyles	248.0	....
Greatest vertical diameter of left condyle	158.0	....
Greatest transverse diameter of left condyle	96.0	....
Distance across skull between outer margins of exoccipitals	700.0	....
Distance between anterior margin of apophysis of supraorbital process of right frontal and posterior margin of right condyle	493.0	....
Distance across basicranium between *foramina ovale*	204.0	....
Total length of vomer	780.0	....
Greatest length of left palatine	238.0	....
Greatest breadth of left palatine	135.0	....
Greatest length of left pterygoid	293.0	....
Greatest length of hamular process of right pterygoid	185.0	....
Greatest transverse diameter of right lachrymal	198.0	151.0[5]
Greatest antero-posterior diameter of right lachrymal	75.0	68.5[5]
Greatest length of right jugal	107.0	62.+
Greatest length of right zygomatic process	198.0	....
Greatest breadth of right alisphenoid at extremity	110.0	....
Greatest depth of right alisphenoid at extremity	30.0	....
Least distance between optic canal and *foramen ovale*	86.0	....
Least distance between optic canal and jugulo-acoustic canal	162.0	....
Greatest diameter of right respiratory passage	48.0	24.0
Greatest diameter of left respiratory passage	85.0	49.0

[5] Left.

Teeth

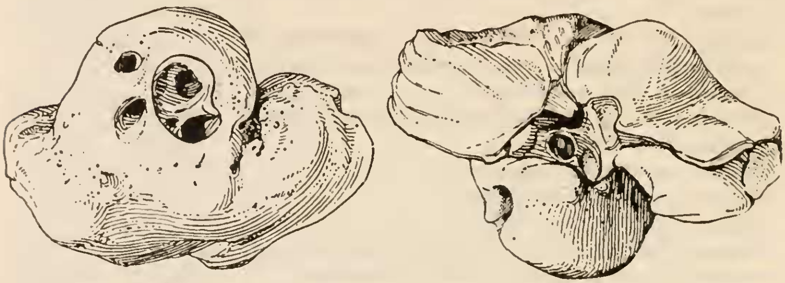
Crown covered with smooth enamel in front and on one side, but wrinkled on opposite side; enamel of crown passes into cement without any perceptible increase or decrease in diameter or neck; root long, backwardly curved, and broadly oval in cross section; pulp cavity closed.

Periotic

None of the periotic bones here discussed was attached to a skull, and were it not for the fact that only one type of physeteroid periotic was represented among the many specimens

obtained from a short trench dug in the uppermost horizon of the Temblor formation, there might be some question as to their allocation. Eight right and three left periotic bones of this physeteroid were obtained at the one locality.

It is remarkable how closely, except for minor modifications in the anterior process, these periotics resemble those of recent sperm whales, for the relative proportions and peculiarities of the various structures are essentially the same. As in other



107 108

Right periotic of *Aulophyseter morricei,* No. 2795, C. A. S., × 0.75. Fig. 107. Cerebral view. Fig. 108. Inferior view.

sperm whales, the periotic may be divided for purposes of description into a very dense external portion, the combined anterior and posterior processes, a lighter internal sub-hemispherical *pars cochlearis* and the *pars vestibularis.* Minor variations in the contour of the articular facet on the posterior process are observable in the eleven periotics under consideration, but most of them may be attributed to the effects of erosion. There are fine osseous crests on the tympanic face of the posterior process which are arranged like rays radiating from a common center on the internal margin. This articular facet is irregular in outline, the posterior margin rather evenly curved, and the external and anterior margins more or less sinuous. The major portion of the posterior facet is concave, but the anterior border slopes obliquely to the groove for the external auditory tube. The ventro-internal border of this process projects inward and the free edge contributes the floor of the facial canal for approximately one-half of its length. The external face of this process is flattened and more or less

rugose. According to the text figure and photographs the right and left periotics reproduced in the memoir by Abel,[57] and which are unfortunately allocated to *Eurhinodelphis longirostris*, it is evident that the distal or external portion of the posterior process is distinctly emarginate and rugose.

There is very little variation in the general outlines of the *pars cochlearis* (fig. 108), as seen from a ventral view, in these eight periotics. Whatever differences are observable are of a minor nature. There is a low, short crest or nodosity near the middle and on the internal border of the *pars cochlearis* on nine of these periotics, which may have resulted from contact with the involucrum of the tympanic. The major portion of the ventral face of the *pars cochlearis* is more or less flattened and slopes toward the anterior margin, with the most inflated point opposite to the *fenestra ovalis*. The external face is flattened and nearly vertical. From a tympanic view, three apertures are visible, and, of these, the largest is the *fenestra rotunda* on the posterior face of the labyrinthic region. This fenestra is crescentic in outline, with a rounded nodosity above which partially closes the opening. The *fenestra ovalis* is ovoidal in outline and is situated near the center of the tympanic face of the periotic. A narrow rim which is raised above the canal for the facial nerve and the fossa for the stapedial muscle encircles the fenestra on the outside. The foot plate of the stapes completely fills the fenestra. A medium sized internal passage, which leads from the vestibule, and a pair of minute antero-external foramina, leading to the semicircular canals, also open into the vestibule. The minute aqueduct leading from the *foramen singulare* opens near the bottom of the vestibule on the internal wall and near the anterior angle. The epitympanic orifice of the *aquæductus Fallopii* and the *fenestra ovalis* lie in a depression, although the former is largely concealed from a ventral view by the projecting ledge of the *fossa incudis*. Posterior to this orifice, the facial canal is open along its whole length, sloping obliquely downward and curving around the posterior face of the posterior process. Posteriorly, the facial canal borders on a large semi-enclosed fossa for the stapedial muscle. The fossa for the

[57] O. Abel, Les dauphins longirostres du Boldérien (Miocène supérieur) des environs d'Anvers. Mem. Mus. Roy. d'Hist. Nat. Belgique, vol. 2, 1902, pp. 121-123, text fig. 19; pl. 17, figs. 11-12.

stapedial muscle is a deep concavity and the surface for the attachment of the muscle extends downward upon the external face of the *pars cochlearis*. A thin-edged crest is developed on the ventro-external angle of the labyrinthic region by the encroachment of the fossa for the stapedial muscle. This thin curved crest, which rises behind the stapedial fossa, has been destroyed on eight of these periotics, including that associated with the type skull, but is well preserved on three. Between the *fenestra ovalis* and the deep concave fossa for the head of the malleus, there is a narrow crescentic excavation which commences near the epitympanic orifice of the *aquæductus Fallopii* and extends downward on the external face of the *pars cochlearis* to its tympanic face. Between the rounded tuberosity or swelling on the anterior process and the anterior border of the articular facet on the posterior process, the ventral surface of the external denser portion of the periotic is hollowed out, becoming distinctly grooved as it approaches the *fossa incudis*. On seven of these periotics the *fossa incudis* is preserved in its entirety, but it has been damaged on the periotic associated with the type skull. This small shallow elliptical fossa is situated at the extremity of the thin ledge which projects inward below the facial canal. The *fossa incudis* receives the *crus breve* of the incus.

The extremity of the anterior process resembles the handle end of a crutch when viewed from in front. This peculiarity is produced by two projecting points, the external and internal angles. There is a crease, more distinct on some than on others, on the posterior face of the tuberosity external to the epitympanic orifice of the *aquæductus Fallopii*. The external face of the anterior process is rounded off between this tuberosity and the apex of the process. Anterior to the fossa for the head of the malleus, the ventral surface of the anterior process is deeply concave from end to end and more or less flattened from side to side. The relatively large accessory ossicle or unciform process of the tympanic is lodged in this fossa. Accessory ossicles were present on all eleven of these periotics. The accessory ossicle is relatively large, almost egg-shaped, with a longitudinal groove marking the line of ankylosis with the external lip of the tympanic, and fusing with the anterior process of the periotic along its posterior and

external margins. If this ossicle is forcibly removed, small portions of the corresponding surface of the anterior process break away with it. When the accessory ossicle is in position, it contributes the outer wall of the deep notch between it and the *pars cochlearis*.

Most of the depressions and nodosities observed on the denser external portion of the cerebral face of the periotic do not appear to have any deep seated significance. Four of these periotics have a rather prominent pyramidal tuberosity arising external to the orifice of the *aquæductus vestibuli* and three do not exhibit any trace of this nodosity. On two there is a large nodosity external to the entrance to the *aquæductus Fallopii*. On all of these periotics a broad groove, irregular in appearance because of the presence of small nodosities, traverses the anterior process in front of the *pars cochlearis*. From a cerebral view the posterior process appears rather slender and the anterior process very robust; the *pars cochlearis* is inclined forward. An irregular crease defines the limits of the *pars vestibularis* and the posterior process on the cerebral face of the periotic. The *pars vestibularis* is relatively small; its external surface is concealed by the anterior and posterior processes, and internally it is continuous with the *pars cochlearis*.

A rather instructive example of how slight changes in the growth of a bony partition between the entrance to the *aquæductus Fallopii* and the more centrally placed *tractus spiralis foraminosus* can modify the contour of the internal acoustic meatus is shown in these eleven periotics. The internal acoustic meatus of the periotic (fig. 107) used for illustration represents the average type. In the majority of these periotics the rim of the internal acoustic meatus is pyriform in outline. In others a thin partition or transverse crest is interposed between the entrance to the *aquæductus Fallopii* and the fossa bounding the spiral tract. The outer edge of this transverse crest is almost continuous with the rim of the meatus and imparts a distinctly ovoidal outline to the latter. The largest and most external of the orifices which appear on the cerebral face is that of the *aquæductus Fallopii*, which pierces the substance of the periotic and through which passes the facial nerve to emerge on the tympanic face slightly anterior to the *fenestra ovalis*. Internal to the entrance to the *aquæductus Fallopii* is

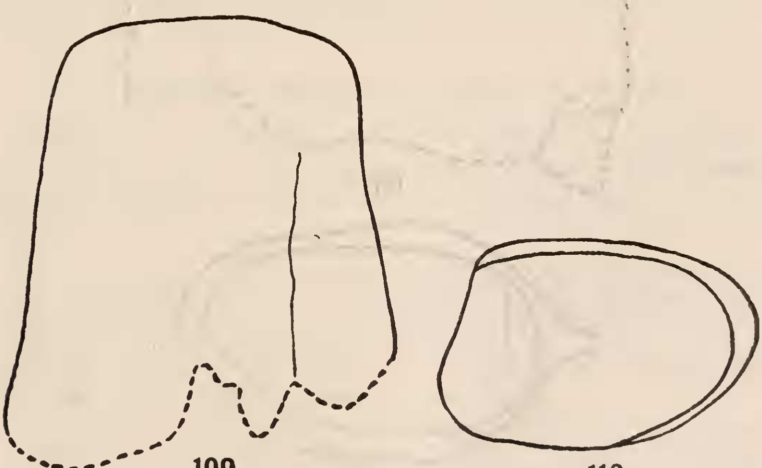
Measurements of Periotics (in millimeters)

	No. 11230, U.S.N.M. Right (type)	No. 10853, U.S.N.M. Right	No. 2798, C. A. S. Right	No. 2795, C. A. S. Right	No. 2794, C. A. S. Right	No. 2797, C. A. S. Right	No. 2799, C. A. S. Left	No. 2800, C. A. S. Right	No. 2801, C. A. S. Right
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	25.2	26.0	25.1	28.5	25.0	27.8	26.1	27.0	23.1
Greatest length of periotic (tip of anterior process to tip of posterior process)	38.1	41.+	37.6+	42.0	36.2	......	......	42.5+	36.7+
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	21.0	19.5	19.0	17.0	16.8	19.7	17.5	21.3	17.9
Distance between *fenestra rotunda* and tip of anterior process	26.8	29.1	26.1	28.3	26.0	28.7	27.6	28.0	25.0
Distance between *fenestra rotunda* and tip of posterior process	19.+	22.9+	18.3	20.2	17.2	......	......	21.5	18.0
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	18.8	21.5	20.0	21.5	19.1	21.2	19.4	20.7	18.7

the deep internal acoustic meatus, on the bottom of which is the *tractus spiralis foraminosus* and the minute *foramen centrale.* On the external wall of this meatus and about half-way between the rim and the bottom is a small compressed *foramen singulare.* A relatively thin partition or transverse crest, whose outer margin may or may not be depressed below the level of the rim of the internal acoustic meatus, places the orifice of the *aquæductus vestibuli* outside of and posterior to the meatus. This orifice is compressed and opens into a slit-like fossa. The cerebral orifice of the *aquæductus cochleæ* is considerably larger than that for the *aquæductus vestibuli,* and the interval between these orifices varies from 2 to 3.8 mm.

Radius

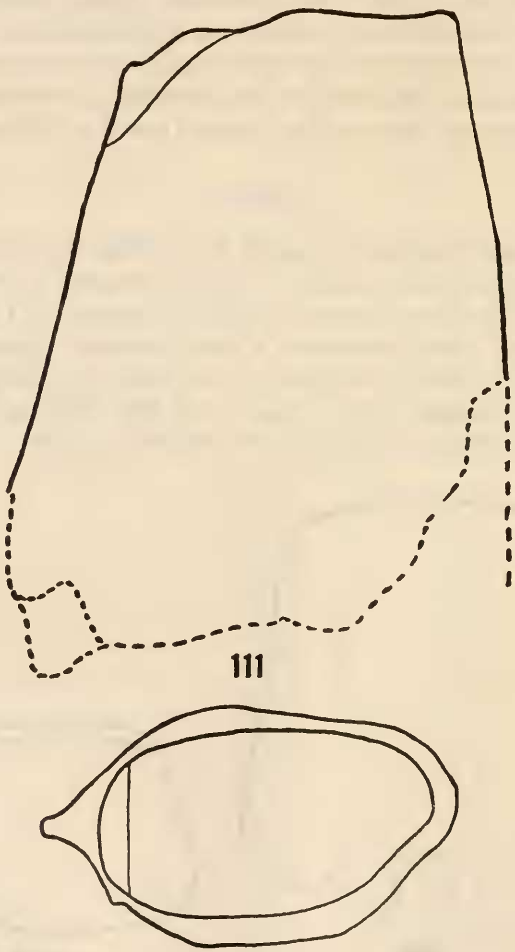
Two radii that lack the distal end of the shaft are referred to this fossil sperm whale. They correspond in shape with those of *Physeter catodon* and differ from those of all known cetotheres. Each radius has a thin proximal epiphysis comprising the articular surface for the humerus. This articular surface is rugged and is flush with the external or lateral margin, but slopes abruptly to the internal margin. The hemi-



109 110

Proximal end of right radius of (?) *Aulophyseter morricei,* No. 4444, C. A. S., × 1.0. Fig. 109. External view. Fig. 110. Proximal view.

circular facet for the ulna at the proximal end of the posterior face is depressed mesially. The shaft is flattened from side to side. The facet for the humerus on the largest radius (No. 4445, C. A. S.) measures 74.4 mm. antero-posteriorly and 54 mm. transversely. The same measurements for the smaller radius (No. 4444, C. A. S.) are 68 mm. and 48.5 mm., respectively.



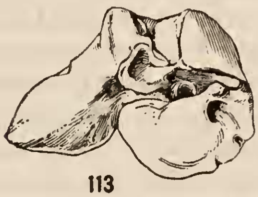
111

112

Proximal end of right radius of (?) *Aulophyseter morricei,* No. 4445, C. A. S., × 1.0. Fig. 111. External view. Fig. 112. Proximal view.

Family SQUALODONTIDÆ: Shark-toothed Porpoises

The two ear bones hereinafter described are referred to the genus *Squalodon,* for reasons which are almost indefinable, and yet all known squalodonts have similar peculiarly shaped periotics. The subtile characters that distinguish the periotics of squalodonts from those of other porpoises are apparent to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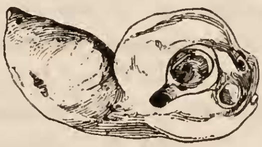
114

Left periotic of *Squalodon errabundus,* No. 11573, U. S. N. M., × 1.0. Fig. 113. Inferior view. Fig. 114. Cerebral view.

anyone who has studied these bones, although it is difficult to point out any tangible feature which will invariably identify them. This appears to be the first published occurrence of a representative of this family in Tertiary deposits on the Pacific Coast of North America. Remains of squalodonts have been found in Australia and New Zealand.

12. **Squalodon errabundus**[58] Kellogg, new species

Holotype: Left periotic, No. 11573, Division of Vertebrate Paleontology, U. S. Nat. Mus. from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924.

Aside from the loss of the posterior process, the type periotic is exceptionally well preserved. Both processes are broken off on a second left periotic (No. 11574, U. S. N. M.) referred to this species. Very little variation can be observed in corresponding parts of these two periotics.

Diagnosis: Viewed from the ventral side (fig. 113) the *pars cochlearis* is convex, although it is depressed opposite the *fenestra ovalis,* and the posterior face slopes abruptly to the cerebral margin above the large *fenestra rotunda.* The narrow

[58] *Errabundus,* wanderer.

external rim of the *fenestra ovalis* is not complete and is depressed below the channel for the facial nerve. The epitympanic orifice of the aqueduct of Fallopius is relatively small. A portion of the stapedial fossa and most of the groove for the facial nerve extend over upon the missing posterior process of the type periotic. The fossa for the stapedial muscle is deep, rather small, and extends downward upon the outer wall of the *pars cochlearis;* it stops anteriorly at the narrow external rim of the *fenestra ovalis.* A sharp-edged crest is developed on its internal margin. It is possible that the second periotic may be abnormal in one respect, for the above mentioned sharp-edged crest, which forms the inner border of the stapedial fossa, is appressed posteriorly to the posterior process, forming an aqueduct through which the facial nerve passed in its outward course. No recent or fossil porpoise, known to the writer, has a periotic modified in this manner. The excavation on the outer denser portion of the periotic between the posterior process and the tuberosity is very narrow and deep. The narrow projecting ledge, on which the *fossa incudis* is situated, is damaged on both periotics. Between the pointed extremity and the constriction in front of the tuberosity, the anterior process swells out on the cerebral side, forming a large protuberance. On the internal side of the narrow tuberosity is a large concavity for lodging the head of the malleus.

Some of the distinguishing features of the periotic of this porpoise, as compared with that of *Squalodon calvertensis,*[59] are the position of the fossa inclosing the orifice of the *aquæductus vestibuli,* the shape of the anterior process, the relative size of the *pars cochlearis,* and the cucurbital outline of the internal acoustic meatus. A low broad transverse crest (fig. 114) separates the large entrance to the aqueduct of Fallopius from the more centrally placed fossa for the *tractus spiralis foraminosus.* The *foramen centrale* pierces the transverse crest at its external angle. Outside and external to the internal acoustic meatus is a deep fossa into which the aqueduct of the vestibule opens. The small circular orifice of the cochlea is equally distant from the rim of the meatus. The cerebral and external faces of the outer denser portion of the periotic form

[59] R. Kellogg, Proc. U. S. Nat. Mus., vol. 62, publ. 2462, 1923, text fig. 3, and pl. 8, fig. 6.

a continuous smooth convex surface, imparting the characteristic shape to this ear bone.

Measurements of Periotics (in millimeters)

	No. 11573, U. S. N. M. Left (type)	No. 11574, U. S. N. M. Left
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*).............................	25.7	24.0
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face).............................	14.1	15.0
Distance between *fenestra rotunda* and tip of anterior process....................................	28.0	....
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process.............	23.8	....

Family DELPHINIDÆ: Porpoises

13. **Liolithax kernensis**[60] Kellogg, new genus and species

Holotype: Left periotic, No. 4340, Mus. Calif. Acad. Sci., from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924. *Paratype:* No. 11565, Division of Vertebrate Paleontology, U. S. Nat. Mus.

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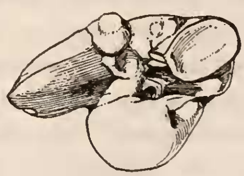

116

Left periotic of *Liolithax kernensis,* No. 4340, C. A. S., × 1.0. Fig. 115. Cerebral view. Fig. 116. Inferior view.

[60] λειος, smooth; Λιθαξ, diminutive of λιθος, a small stone, in allusion to the dense periotic bone; *kernensis,* the Kern River region.

Diagnosis: Four left periotics are known for this species, two of which belong to the California Academy of Sciences and two to the United States National Museum. One of the specimens in the California Academy of Sciences is imperfect and somewhat worn. In general, the periotic of this porpoise seems to be characterized by the direction of the facet on the ventral face of the posterior process, by the prolongation of the antero-ventral angle of the anterior process to support the outer lip of the bulla, by the transverse crease on the ventral surface of the anterior process which marks the anterior limit of the tuberosity, by the presence of a deep incisure on the posterior face above and internal to the stapedial fossa, and by the constriction of the entrance to the *aquæductus Fallopii.*

The ventral facet of the posterior process is badly worn on all four of these periotics, but it is most nearly complete on the one here figured (fig. 116). This facet slopes from the apex to the base and is shallowly concave; the ventro-internal margin is raised and the postero-internal angle overhangs the groove for the facial nerve. The posterior and external faces of the posterior process form a continuous curve. The *pars cochlearis* is relatively smaller than in *Platylithax robusta*, and externally it rises more abruptly from the *fenestra ovalis*. The *fenestra rotunda* is circular in outline and produces a slight indentation, although the *pars cochlearis* is not noticeably inflated in the region of the aqueduct of the cochlea. The rim of the *fenestra ovalis* is very narrow, but the raised border which separates it from the channel for the facial nerve, and the fossa for the stapedial muscle is rather broad. Within the vestibule can be seen the small orifices of the semicircular canals and the terminal opening of the *foramen singulare*. The epitympanic orifice of the *aquæductus Fallopii* is placed above the antero-internal angle of the fossa for the head of the malleus, and the channel for the facial nerve leading backward from it is sharply defined anteriorly, but posteriorly its margins become rather indistinct. The fossa for the stapedial muscle encroaches internally upon the *pars cochlearis,* resulting in the formation of a crest posterior and external to the *fenestra rotunda*.

The *fossa incudis* (fig. 116) for the *crus breve* of the incus is very narrow and occupies a thin ledge. Externally a thin carina separates this fossa from the excavation on the outer denser portion of the periotic between the posterior process and the tuberosity. The anterior process is furnished with a pointed tongue-like process which projects inferiorly beyond the rounded extremity. On three of these periotics the ventral surface of this pointed process is grooved longitudinally to provide additional support for the outer lip of the bulla. The accessory ossicle of the bulla rests on the ventral surface of the anterior process between the pointed extremity and the tuberosity at the base. The concavity for lodging the head of the malleus has a slight indentation on its external border which is associated with the crease which marks the posterior limit of the tuberosity.

The elongate internal acoustic meatus (fig. 115) is the most prominent structure on the cerebral face. This meatus is

Measurements of Periotics (in millimeters)

	No. 10854, U.S.N.M. Left	No. 4340, C. A. S. Left (Holotype)	No. 4341, C. A. S. Left	No. 11565, U.S.N.M. Left
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	18.2	20.2	....	19.7
Greatest length of periotic (tip of anterior process to tip of posterior process)	29.5+	31.8+	30.+	30.8+
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	13.3	12.8	12.0	12.8
Distance between *fenestra rotunda* and tip of anterior process	20.5	22.0	....	21.8
Distance between *fenestra rotunda* and tip of posterior process	12.5+	14.7+	....	14.2+
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	17.2	18.5	16.8	18.0

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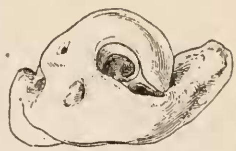
strongly constricted along the entrance to the *aquæductus Fallopii,* and behind this constriction its walls descend obliquely to the kidney shaped fossa which is occupied by the *tractus spiralis foraminosus.* A low partition separates this fossa from the entrance to the aqueduct of Fallopius. On three of these periotics, the slit-like *foramen singulare* is situated on this transverse bony crest, but on the fourth (No. 10854 U. S. N. M.) it is placed near the level of the spiral tract. The cerebral orifice of the *aquæductus vestibuli* opens into a deep triangular fossa and the small circular orifice of the aqueduct of the cochlea is placed much closer to the rim of the internal acoustic meatus. The cerebral and external faces of the outer denser portion of the periotic form a continuously curved surface, without any irregularities. The anterior process, as viewed from the cerebral side, is rather robust and convex.

14. **Œdolithax mira**[61] Kellogg, new genus and species

Holotype: Right periotic, No. 11572, Division of Vertebrate Paleontology, U. S. Nat. Mus. from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924. *Paratype:* Left periotic, No. 11571, Division of Vertebrate Paleontology, U. S. Nat. Mus.



117

118

Right periotic of *Œdolithax mira,* No. 11572, U. S. N. M., × 1.0. Fig. 117. Cerebral view. Fig. 118. Inferior view.

Diagnosis: The periotics referred to this porpoise are in some respects larger replicas of those referred to *Lamprolithax simulans.* Attention is directed to the pronounced inflation of the *pars cochlearis* posterior to the aqueduct of the cochlea, to the depression whose apex is formed by the fossa inclosing the orifice of the aqueduct of the vestibule and whose base is the

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[61] οιδεω, to swell, to become swollen; Λιθαξ, dimunitive of λιθος, a small stone in allusion to the dense periotic bone; *mira,* strange, wonderful.

outer rim of the internal acoustic meatus, to the rather deep pit on the posterior face above the stapedial fossa, and to the antero-posterior diameter of the *pars cochlearis*.

The margins of the ventral facet on the posterior process (fig. 118) of the type periotic are worn and the posterior half, at least, of this process is missing on the paratype periotic. In so far as can be determined from these two specimens, this facet is concave on the basal half, rather wide, and is furnished with a few grooves radiating outward from the raised ventro-internal margin. Viewed from the ventral side, the *pars cochlearis* is most strongly inflated in front of the *fenestra rotunda,* slightly depressed opposite the *fenestra ovalis,* and slopes toward the anterior and inner margins. A low crest is also present on its antero-external border. The *fenestra rotunda* is crescentic in outline and the surface is depressed behind it. The outer narrow rim of the *fenestra ovalis* is incomplete and no carina intervenes between it and the more elevated channel for the facial nerve. In the narrow vestibule are the usual orifices of the small semicircular canals. The channel for the facial nerve, which leads backward from the epitympanic orifice of the *aquæductus Fallopii,* is rather broad and appears to terminate at the postero-internal angle of the posterior process. The deep elongate fossa for the stapedial muscle extends forward to the narrow external rim of the *fenestra ovalis* and is bordered on the internal side by a sharp-edged crest.

The *fossa incudis* is destroyed on the type periotic. On the paratype periotic, the *fossa incudis* is rather small, elliptical in outline, and is raised above the rather narrow and deep excavation on the outer denser portion of the periotic. The anterior process is robust and is bluntly truncated at the extremity. On its ventral surface is the usual mesially elevated cordiform facet for the accessory ossicle of the bulla. The posterior outline of the tuberosity is convex on both periotics, but the type differs from the paratype in having a deep transverse crease on the posterior face of the tuberosity and a corresponding notch in the fossa for the head of the malleus.

Direct comparison of these two periotics with the six periotics referred to *Lamprolithax simulans* revealed some minor differences. The shape of the internal acoustic meatus varies

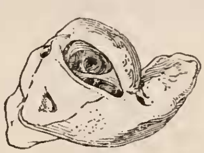
in both species. On the type periotic of *Œdolithax mira* (fig. 117), the entrance to the aqueduct of Fallopius is constricted anteriorly, and, on the paratype, the opposing walls have grown together, but the minute aqueduct leading to the original entrance is still open. The transverse crest extends more than half way to the outer rim of the meatus and posterior to it, but above the deep fossa for the *tractus spiralis foraminosus,* is the *foramen singulare.* Behind the posterior angle of the internal acoustic meatus and on the posterior face of the *pars cochlearis* is the small cerebral orifice of the aqueduct of the cochlea. The fossa inclosing the cerebral orifice of the aqueduct of the vestibule forms the apex of a triangular area which terminates at the outer rim of the internal acoustic meatus. This area is more noticeably depressed on the paratype than on the type periotic. The cerebral and external surfaces of the outer denser portion of the periotic are convex and the extero-ventral border of the anterior process over-rolls the external face.

Measurements of Periotics (in millimeters)

	No. 11572, U. S. N. M. Right, Type	No. 11571, U. S. N. M. Left, Paratype
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	17.6	17.2
Greatest length of periotic (tip of anterior process to tip of posterior process)	29.6+	26.4+
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	9.9	11.1
Distance between *fenestra rotunda* and tip of anterior process	19.4	18.0
Distance between *fenestra rotunda* and tip of posterior process	14.5+	14.7+
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	14.9	14.0

15. **Lamprolithax simulans**[62] Kellogg, new genus and species

Holotype: Right periotic, No. 11566, Division of Vertebrate Paleontology, U. S. Nat. Mus., from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924. *Paratype:* No. 11568, U. S. N. M. *Referred specimens,* No. 11567, U. S. N. M., and Nos. 4344, 4345, 4346, Mus. Calif. Acad. Sci.



119

120

Right periotic of *Lamprolithax simulans,* No. 11566, U. S. N. M., × 1.0.
Fig. 119. Cerebral view. Fig. 120. Inferior view.

Diagnosis: Of the six periotics herewith listed, three are in the collection of the California Academy of Sciences and three in the United States National Museum. Four of these periotics are from the right side and two from the left side. Two of these six periotics have the apex of the depressed subtriangular area behind the internal acoustic meatus produced considerably beyond the fossa inclosing the cerebral orifice of the aqueduct of the vestibule. This apex is foreshortened on the four remaining periotics. From *Lamprolithax annectens* the periotic of this porpoise differs in having the apex of the triangular depressed area behind the internal acoustic meatus produced beyond the fossa which incloses the aqueduct of the vestibule, a smaller *pars cochlearis,* and a more sharply defined crest on the cerebral face of the anterior process.

None of these periotics have the facet on the ventral face of the posterior process complete. This series does show that the ventral facet is traversed by ridges radiating from the raised ventro-internal margin. The posterior face of the posterior process is excavated and the external is obliquely truncated. The remainder of the periotic, viewed from the ventral side (fig. 120), resembles that of *Lampolithax annectens.*

[62] λαμπρος, splendid; Λιθαξ, diminutive of λιθος, a small stone, in allusion to the dense periotic bone; *simulans*, imitating.

Considerable variation in the contour of the internal acoustic meatus may be expected in the periotics of this porpoise, judging from the differences observed in this small series. One (No. 11567, U. S. N. M.) has a very narrow meatus and another (No. 11568, U. S. N. M.) has the outer edge of the transverse bony crest separating the entrance to the aqueduct of Fallopius from the fossa for the spiral tract flush with the level of the rim of the meatus. Four, including the type periotic (fig. 119), have a meatus with essentially the same out-

Measurements of Periotics (in millimeters)

	No. 11566, U.S.N.M. Right, Type	No. 11567, U.S.N.M. Right, Paratype	No. 11568, U.S.N.M. Left,	No. 4344, C. A. S. Right,	No. 4345, C. A. S. Right,	No. 4346, C. A. S. Left
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*..........	16.4	16.1	16.5	16.3	15.9	[1]
Greatest length of periotic (tip of anterior process to tip of posterior process)..	26.3+	26.3+	[1]	25.5+	26.7+	[1]
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)..................	9.6	9.6	9.3	10.0	8.9	......
Distance between *fenestra rotunda* and tip of anterior process..........	17.2	17.4	17.8	17.3	17.0	17.8
Distance between *fenestra rotunda* and tip of posterior process..........	13.2+	13.2+	[1]	14.+	14.+	[1]
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process........	13.3	13.5	14.6	13.8	13.3	13.9

[1] Posterior process missing.

line. The aqueduct of Fallopius and the *foramen singulare* also vary in size, and on two of these periotics they show an increase of two diameters over the smallest. The vestigial original entrance to the aqueduct of Fallopius in the notch between the anterior process and the *pars cochlearis* is open on two of these periotics. In the others this small aqueduct has lost its connection with the functional aqueduct. On five of these periotics the transverse bony crest rises about half way to the outer rim of the internal acoustic meatus and on the sixth, as mentioned above, it is flush with the outer rim. On the last mentioned periotic, the *foramen singulare* is placed on the posterior face of the transverse crest about half way between the bottom of the fossa occupied by the spiral tract and the rim of the meatus. The five remaining periotics have the *foramen singulare* on the outer edge of the transverse crest at the same level and in approximately the same position as on the abnormal periotic. The fossa into which the aqueduct of the vestibule opens is rather large on five of these periotics and on the sixth it is nearly closed. The cerebral orifice of the aqueduct of the vestibule is situated on the posterior face of the *pars cochlearis*. The cerebral face rolls over upon the external face of the outer denser portion of the periotic. A small pit is present on the posterior face above the stapedial fossa.

16. **Lamprolithax annectens**[63] Kellogg, new species

Holotype: Left periotic, No. 4343, Mus. Calif. Acad. Sci., from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924. *Paratype:* Left periotic, No. 4342, Mus. Calif. Acad. Sci.

121

122

Left periotic of *Lamprolithax annectens*, No. 4343, C. A. S., × 1. Fig. 121. Cerebral view. Fig. 122. Inferior view.

[63] *annectens*, connecting.

Diagnosis: One of the two periotics referred to this species lacks most of the posterior process. The periotic of this dolphin has a rather broad internal acoustic meatus, a deep pit on the posterior face above the stapedial fossa, a low crest on the external margin of the ventral or tympanic face of the *pars cochlearis* opposite to the facet for the accessory ossicle, a raised crest on the internal margin of the deep stapedial fossa which projects backward beyond the *fenestra rotunda,* and a flattened area between the orifice of the *equæductus vestibuli* and the posterior rim of the internal acoustic meatus.

The margins of the facet on the ventral face of the posterior process (fig. 122) are eroded on the type periotic and the corresponding portion of the paratype periotic is lost. Ridges radiating outward from the ventro-internal margin traverse this facet. The posterior face of the posterior process is excavated above this articular surface and the external face is flattened. The ventral or tympanic face of the *pars cochlearis* is more or less flattened and is most strongly inflated immediately in front of the *fenestra rotunda.*

The *pars cochlearis* swells out for a distance of 3 mm. behind the kidney-shaped *fenestra rotunda,* but is depressed below the crest which bounds the stapedial fossa on the internal side. The *fenestra ovalis* does not have a complete external rim and the groove for the facial nerve does not sink below the level of the latter as it does on the periotic of *Liolithax kernensis.* The minute orifices of the semicircular canals are located within the vestibule in their usual position. The groove for the facial nerve leading backward from the epitympanic orifice of the *aquæductus Fallopii* terminates at the postero-internal angle of the posterior process. The fossa for the stapedial muscle is deep and elongate.

The narrow *fossa incudis* is placed on a thin projecting ledge which lies below the level of the triangular excavation on the outer denser portion of the periotic between the posterior process and the tuberosity.

The anterior process is directed obiquely forward and inward, compressed from side to side, and bluntly truncated or rounded at the extremity. The cordiform articular surface for the accessory ossicle is bisected by a longitudinal elevation which follows the angle formed by the ventral and internal

faces of the anterior process. On the internal face of the tuberosity is the deep concavity for lodging the head of the malleus.

The cerebral face of this periotic (fig. 121) is characterized by some well marked features. The external margin of the large internal acoustic meatus is nearly straight and the internal margin is curved. Within this meatus are located the relatively large entrance to the *aquæductus Fallopii* and the deep fossa for the spiral tract. Some 3 mm. in front of the internal acoustic meatus is a small pit which is a remnant of a former entrance to the aqueduct of Fallopius. A broad transverse crest, which rises about half way to the outer rim of the meatus, separates the entrance to the aqueduct of Fallopius from the *tractus spiralis foraminosus*. The small *foramen singulare* is situated on the outer edge of this bony partition. Behind the rim of the internal acoustic meatus is a rather large flattened triangular area having its apex formed by the fossa which surrounds the cerebral orifice of the aqueduct of the vestibule. The small aqueduct of the cochlea has its cere-

Measurements of Periotics (in millimeters)

	No. 4343, C. A. S. Left, Type	No. 4342, C. A. S. Left
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	18.0	17.5
Greatest length of periotic (tip of anterior process to tip of posterior process)	27.9+	([1])
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	10.2	10.7
Distance between *fenestra rotunda* and tip of anterior process	19.1	18.9
Distance between *fenestra rotunda* and tip of posterior process	12.6+	([1])
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	14.8	14.5

[1] Posterior process missing.

bral orifice on the posterior face of the *pars cochlearis* behind the postero-internal angle of the internal acoustic meatus. The external face is considerably broader than the cerebral face of the outer denser portion of the periotic. On the cerebral face of the anterior process is a longitudinal crest.

17. **Nannolithax gracilis**[64] Kellogg, new genus and species

Holotype: Right periotic, No. 11569, Division of Vertebrate Paleontology, U. S. Nat. Mus.

Diagnosis: Two periotics of this porpoise have been collected, one of which lacks most of the *pars cochlearis,* and the exact relationships of the species to those heretofore described remains to be determined. They do resemble some small periotics from the "molasse" of Baltringen near Biberach, in Württemberg, described and figured by Probst.[65]

123

124

Right periotic of *Nannolithax gracilis,* No. 11569, U. S. N. M., × 1. Fig. 123. Cerebral view. Fig. 124. Inferior view.

Unlike the periotic of *Grypolithax obscurus,* which bears a general resemblance to it, this diminutive ear bone is decidedly angular and the anterior process is strongly compressed from side to side distally. Some of the more important characters of this periotic are the compressed outline of the internal acoustic meatus, the attenuation of the anterior process, the relatively large size of the epitympanic orifice of the *aquæductus Fallopii,* and the absence of a pit on the posterior face above the stapedial fossa.

The ventral facet on the posterior process of the type periotic (fig. 124) is worn smooth, but fortunately that area is

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[64] *ναννος*, dwarf; Λιθαξ, diminutive of λιθος, a small stone, in allusion to the dense periotic bone; *gracilis*, slender.

[65] J. Probst, Ueber die Ohrenknochen fossiler Cetodonten aus der Molasse von Baltringen O. A. Laupheim. Jahreshefte d. Ver. f. vaterl. Naturk. Württ., 1888, pp. 51-52, pl. 2, figs. 12-15.

fairly well preserved on the second periotic. This articular surface is subtriangular in outline, concave in a fore and aft direction, and its raised ventro-internal margin overhangs the channel for the facial nerve. The posterior face of the posterior process is flattened and the external is convex. The ventral surface of the *pars cochlearis* is convex and slopes in an antero-internal direction. The *fenestra rotunda* is large, circular in outline, and does not modify the posterior outline of the *pars cochlearis* to any appreciable extent. The external narrow rim of the *fenestra ovalis* is indistinct. The deep vestibule is provided with the usual orifices for the small semicircular canals. A low carina separates the groove for the facial nerve from the *fenestra ovalis* anteriorly and the stapedial fossa posteriorly. The groove for the facial nerve is rather broad and terminates at the postero-internal angle of the posterior process. The elongate fossa for the stapedial muscle ends anteriorly at the outer rim of the *fenestra ovalis,* laterally it extends downward upon the external face of the *pars cochlearis* and the internal face of the posterior process, and is also bounded on the internal side by a low crest.

The anterior and posterior halves of the *fossa incudis* meet at an obtuse angle mesially. Anteriorly this fossa occupies a narrow projecting ledge, and, posteriorly, on the antero-internal margin of the posterior process, it expands into a somewhat broader and deeper pit. In front of the abruptly truncated anterior face of the posterior process, the surface of the excavation on the outer denser portion of the periotic rises gradually to the crest of the tuberosity and is shut off internally from the epitympanic recess by the raised margin of the *fossa incudis.* The anterior process is attenuated, strongly compressed from side to side distally, and its ventral surface is furnished with a mesially elevated cordiform articular surface for the accessory ossicle of the bulla. On the internal face of the crest-like tuberosity is a rather large concavity for lodging the head of the malleus.

Within the narrow internal acoustic meatus (fig. 123) is a low transverse crest which separates the compressed entrance to the aqueduct of Fallopius from the fossa occupied by the *tractus spiralis foraminosus.* On the outer edge of the transverse crest and at the postero-external angle is the rather large

foramen singulare. The external denser portion of the periotic presents a two-sided, flattened cerebral surface, the inner one of which borders the internal acoustic meatus and the outer overrolls the external face. The aqueduct of the vestibule opens into a deep fossa and the aqueduct of the cochlea terminates below the level of the cerebral face. The external face of the anterior process is flattened and the cerebral face is rounded.

Measurements of Periotics (in millimeters)

	No. 11569, U. S. N. M. Right, Type	No. 11570, U. S. N. M. Left
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	14.2	([1])
Greatest length of periotic (tip of anterior process to tip of posterior process)	23.8+	22.+
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	8.8	....
Distance between *fenestra rotunda* and tip of anterior process	16.8	16.3
Distance between *fenestra rotunda* and tip of posterior process	11.7+	10.4+
Distance between epitympanic orifice of *aquaductus Fallopii* and tip of anterior process	12.5	12.8

[1] *Pars cochlearis* damaged.

18. **Platylithax robusta**[66] Kellogg, new genus and species

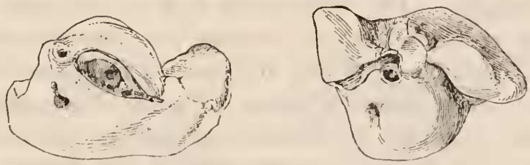
Holotype: Right periotic, No. 4339, Mus. Calif. Acad. Sci., from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924.

Diagnosis: Upon comparing this fossil periotic with those of living porpoises it was found that the periotic of *Delphinus delphis* exhibits the closest approach in general size and shape. This fossil periotic is characterized by a flattened and de-

[66] πλατυς, broad, flat; Λιθαξ, diminutive of λιθος, a small stone, in allusion to the dense periotic bone; *rubusta*, robust.

pressed area external to the internal acoustic meatus, by having the cerebral and external faces nearly at right angles to each other, and by the swelling behind the cerebral orifice of the cochlea.

The margins of the facet on the ventral face of the posterior process (fig. 126) for the corresponding process on the bulla are eroded, but it is apparent that it was originally smaller



125 126

Right periotic of *Platylithax robusta*, No. 4339, C. A. S., × 1.0. Fig. 125. Cerebral view. Fig. 126. Inferior view.

than the corresponding facet on the periotic of *Delphinus delphis*. The ventro-internal margin of the posterior process is raised, the posterior face is flattened, and the external face is rounded. The *pars cochlearis* is rather large, convex, slightly inflated, and externally the surface slopes gradually to the *fenestra ovalis*. The *fenestra rotunda* is relatively small, hemi-circular in outline, and is placed on a line with the anterior margin of the stapedial fossa. The *fenestra ovalis* is encircled by a narrow rim which is depressed below the raised margins of the facial canal and the stapedial fossa. Within the vestibule are the usual openings of the semicircular canals. The epitympanic orifice of the *aquæductus Fallopii* is placed on a line with the anterior margin of the *fenestra ovalis,* and the canal for the facial nerve leading backward from it is partially concealed by the *fossa incudis* and the ventro-internal margin of the posterior process. The fossa for the stapedial muscle is about as wide as the *fenestra rotunda* and extends downward upon the external face of the *pars cochlearis*.

The *fossa incudis* occupies the narrow ledge between the antero-internal angle of the posterior process and the epitympanic orifice of the *aquæductus Fallopii*. The robust anterior process is flattened externally and rounded at the extremity. The ventral face of the anterior process is furnished with a

large articular surface for the accessory ossicle of the bulla as well as the usual concavity for lodging the head of the malleus. The excavation between the posterior process and the tuberosity at the base of the anterior process is shut off from the epitympanic recess by the *fossa incudis*.

Viewed from the cerebral side (fig. 125), this periotic presents a compressed internal acoustic meatus, a robust anterior process, and a flattened surface external to the acoustic meatus. The spiral tract and the foramen singulare are placed at the bottom of the internal acoustic meatus, and they are separated from the entrance to the *aquæductus Fallopii* by a low transverse crest. The cerebral orifice of the *aquæductus vestibuli* is compressed and is separated by an interval of 3.6 mm. from the rim of the internal acoustic meatus. Behind the minute cerebral orifice of the aqueduct of the cochlea is a sub-conical swelling.

Measurements of the right periotic

Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	18.9 mm.
Greatest length of periotic (tip of anterior process to tip of posterior process)	30.+mm.
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	12.6 mm.
Distance between *fenestra rotunda* and tip of anterior process	20.0 mm.
Distance between *fenestra rotunda* and tip of posterior process	15.5+mm.
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	16.3 mm.

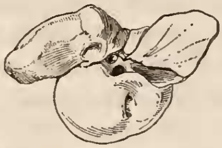
19. **Loxolithax sinuosa**[67] Kellogg, new genus and species

Holotype: Left periotic, No. 4352. *Paratype:* Left periotic, No. 4351, Mus. Calif. Acad. Sci. from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924.

[67] λοξος, slanting; Λιθαξ, diminutive of λιθος, a small stone, in allusion to the dense periotic bone; *sinuosa*, sinuous.

Diagnosis: Superficially these periotics bear a rather close resemblance to the periotic of *Grypolithax pavida.* They are remarkable for the angularity of their processes. The periotic of this porpoise has a broad facet on the ventral face of the posterior process, a relatively wide *fossa incudis,* an elongated internal acoustic meatus, a large fossa surrounding the cerebral orifice of the aqueduct of the vestibule, and an anterior process with a laterally compressed extremity.

127



128

Left periotic of *Loxolithax sinuosa,* No. 4352, C. A. S., × 1.0. Fig. 127. Cerebral view. Fig. 128. Inferior view.

129

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Left periotic of *Loxolithax sinuosa,* No. 4351, C. A. S., × 1.0. Fig. 129. Cerebral view. Fig. 130. Inferior view.

Since the posterior process of the paratype periotic (fig. 130) has a much eroded ventral articular facet, the description of this structure will be based upon the type periotic (fig. 128). The ventral facet of the latter is exceptionally well preserved, the internal and posterior margins are nearly straight, but the anterior and external margins form a continuous curve. The articular surface slopes toward the diagonal depression extending from the apex to the antero-internal angle. The ventro-internal margin of the posterior process is raised and contributes the floor for the groove which lodges the facial nerve in that region. The posterior face of the posterior process is concave and the external is convex. The *pars cochlearis,* viewed from the ventral side, is convex with a shallow depres-

sion opposite the *fenestra ovalis*. Behind the *fenestra rotunda* the posterior surface of the *pars cochlearis* slopes to the cerebral margin. The elliptical *fenestra ovalis* is completely encircled by a narrow rim, and the whole structure is depressed below the groove for the facial nerve. The vestibule is deepest between the minute orifices of the semicircular canals. The fossa for the stapedial muscle is relatively deep and is bordered on the internal side by a sharp-edged crest. A slit-like depression is present on the posterior face above the stapedial fossa. The rather large *fossa incudis* occupies the thin ledge forming the lower boundary of the channel for the facial nerve in the region between the antero-internal angle of the ventral facet of the posterior process and the epitympanic orifice of the *aquæductus Fallopii*. The inner and outer margins of the *fossa incudis* are raised. The excavation between the posterior process and the tuberosity on the outer denser portion of the periotic is rather narrow and deep. The accessory ossicle of the bulla articulates with the anterior process on a cordiform facet, unevenly bisected by a longitudinal elevation. The distal end of the anterior process is compressed from side to side and the extremity is irregularly rounded. The tuberosity has a rounded posterior face, and the internal face bears the usual concavity for lodging the head of the malleus.

Viewed from the cerebral side (figs. 127, 129), the most obvious peculiarities are the side to side compression of the anterior process, the degree of concavity of the posterior face of the posterior process, the inflation of the *pars cochlearis* posterior to the aqueduct of the cochlea, and the shape of the internal acoustic meatus. The internal outline of the *pars cochlearis* is regularly curved. On the paratype periotic (fig. 129) the transverse crest separating the entrance to the aqueduct of Fallopius from the fossa occupied by the *tractus spiralis foraminosus* attains the level of the inner rim of the internal acoustic meatus, but it is depressed below the level of the latter externally. The *foramen singulare* pierces the external wall of the acoustic meatus above the level of the spiral tract. The type periotic has a much lower transverse crest, and the *foramen singulare* is placed on the outer edge of the latter. The entrance to the aqueduct of Fallopius is large and retains its connection with the groove which marks its original

course, although the latter is much reduced in size. A relatively broad interval separates the triangular fossa into which the aqueduct of the vestibule opens from the rim of the internal acoustic meatus. The small cerebral orifice of the aqueduct of the cochlea is placed on the posterior face of the *pars cochlearis* behind a tuberosity which has been developed at the posterior angle of the rim of the internal acoustic meatus.

Measurements of Periotics (in millimeters)

	No. 4352, C. A. S. Left Type	No. 4351 C. A. S. Left Paratype
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	16.8	16.3
Greatest length of periotic (tip of anterior process to tip of posterior process)	29.6+	28.0 28.+
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	10.0	10.5
Distance between *fenestra rotunda* and tip of anterior process	18.1	17.8
Distance between *fenestra rotunda* and tip of posterior process	15.8+	14.9+
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	14.2	14.2

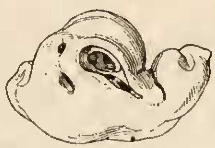
20. **Grypolithax obscura**[68] Kellogg, new genus and species

Holotype: Right periotic, No. 4349. *Paratype:* Left periotic, No. 4347, Mus. Calif. Acad. Sci. from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924.

Diagnosis: Five periotics are referred to this genus, four of which are from the left side and one from the right side. It is not improbable that future discoveries will show that two genera are included in this small series of periotics, for the

[68] γρυπος, curved; Λιθαξ, diminutive of λιθος, a small stone, in allusion to the dense periotic bone; *obscura*, obscure or unknown.

two referred to *Grypolithax obscura* present a quite different contour from the three referred to *Grypolithax pavida.* For the present and in the absence of specific information in regard to cranial peculiarities, all of these periotic bones will be referred tentatively to this genus. The contours of the two periotics referred to this species are more rounded and less angular than those heretofore or hereinafter described, the pyriform internal acoustic meatus is strongly constricted anteriorly, the excavation on the outer denser portion of the periotic between the posterior process and the tuberosity is very narrow internally where it is shut off from the epitympanic recess by the *fossa incudis,* and the *pars cochlearis* is expanded behind the level of the aqueduct of the cochlea.



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Right periotic of *Grypolithax obscura,* No. 4349, C. A. S., × 1.0. Fig. 131. Cerebral view. Fig. 132. Inferior view.

The postero-external angle or apex of the posterior process (fig. 132) is missing on the type periotic. Most of the outwardly projecting apex of this process is preserved on the paratype periotic (No. 4347, C. A. S.). In its original condition the ventral facet on the posterior process was no doubt longer than wide, shallowly concave at the base, and bounded by raised ventro-internal and anterior margins. The posterior and external faces of the posterior process above this facet are convex. The ventral or tympanic face of the *pars cochlearis* is convex and rises rather abruptly from the *fenestra ovalis.*

The *fenestra rotunda* is larger than the *fenestra ovalis* and produces an indentation on the posterior face of the *pars cochlearis.* The narrow external rim of the *fenestra ovalis* is complete. Within the shallow vestibule can be seen the minute orifices of the semicircular canals. The epitympanic orifice of the aqueduct of Fallopius is small, and the groove leading backward from it for the facial nerve does not sink below the level of the rim of the *fenestra ovalis* and is separated from

the latter by a low carina. The fossa for the stapedial muscle is elongate and encroaches anteriorly upon the rim of the *fenestra ovalis,* and internally upon the outer wall of the *pars cochlearis.* A sharp-edged crest bounds this fossa internally. There is a depression but no pit on the posterior face above the stapedial fossa as in *Grypolithax pavida.*

The *fossa incudis* is small and is bounded externally by a short carina. The posterior wall of the excavation on the outer denser portion of the periotic between the posterior process and the tuberosity rises more abruptly than the anterior wall. The anterior process is rather robust, attenuated, and roughly three-sided on the distal third, and is furnished with a nipple-like tuberosity on the extremity. The articular surface for the accessory ossicle of the bulla is elongated and rather deeply impressed.

From a cerebral view the *pars cochlearis* (fig. 131) is seen to be not as strongly arched as in *Lamprolithax simulans,* the surfaces of the outer denser portion of the periotic are more rounded, the entrance to the aqueduct of Fallopius is strongly

Measurements of Periotics (in millimeters)

	No. 4349, C. A. S. Right Type	No. 4347, C. A. S. Left Paratype
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	16.4	17.2
Greatest length of periotic (tip of anterior process to tip of posterior process)	27.1+	28.7+
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	11.2	11.9
Distance between *fenestra rotunda* and tip of anterior process	17.0	19.0
Distance between *fenestra rotunda* and tip of posterior process	13.2+	15.4+
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	13.9	15.2

compressed, and the internal face of the anterior process is creased. The internal acoustic meatus is narrowly pyriform in outline, rather deep, and incloses a reniform fossa which is occupied by the spiral tract. The transverse crest is low, rather broad, and is pierced at the postero-external angle by the small *foramen singulare*. The fossa which incloses the cerebral orifice of the aqueduct of the vestibule is narrow and rather deep. and near it in the usual position is the corresponding orifice of the aqueduct of the cochlea. The *pars cochlearis* swells out behind the level of these orifices.

21. **Grypolithax pavida** Kellogg, new species

Holotype: Left periotic, No. 4348. *Paratypes:* No. 4350, Mus. Calif. Acad. Sci., and No. 11575, Division of Vertebrate Paleontology, U. S. Nat. Mus., from **Sharktooth Hill, Kern County, California**; Temblor Miocene; Charles Morrice, Coll., 1924.

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Left periotic of *Grypolithax pavida,* No. 4348, C. A. S., × 1.0. Fig. 133. Cerebral view. Fig. 134. Inferior view.

Diagnosis: On direct comparison, the periotics of this porpoise as a rule are separable from those of *Grypolithax obscura* by the presence of an irregularly flattened area on the cerebral face of the outer denser portion of the periotic, a broader excavation between the posterior process and the tuberosity, a low crest on the antero-external border of the ventral face of the *pars cochlearis,* and a more rounded extremity of the anterior process.

It seems unnecessary to give a detailed description of the periotic of this porpoise inasmuch as most of it would be merely a repetition of the preceding description. Attention is directed to the presence of a slit-like pit on the posterior face above the stapedial fossa on two of these periotics (Nos. 4348,

4350, C. A. S.), but on the third (No. 11575, U. S. N. M.) it is barely discernible. The posterior and external faces of the posterior process immediately above the ventral facet are shelving. The inflation of the *pars cochlearis* posteriorly is accentuated by a short crease which commences at the inner angle of the crescentic *fenestra rotunda* and proceeds inward in the general direction of the aqueduct of the cochlea. The articular surface (fig. 134) for the accessory ossicle of the bulla is subcordiform in outline, with a medial longitudinal elevation. Opposite this facet and on the ventral face of the *pars cochlearis* is a low crest which is quite distinct on two of these periotics (Nos. 4348, C. A. S., and 11575, U. S. N. M.), but is rather indistinct on the third (No. 4350, C. A. S.). On the type periotic (fig. 133), the closure of the opposing walls of the original entrance to the aqueduct of Fallopius has been completed, leaving a minute orifice on the anterior margin of the *pars cochlearis*. The two remaining periotics illustrate the manner in which this closure has been accomplished.

Measurements of Periotics (in millimeters)

	No. 4348, C. A. S. Left Type	No. 4350, C. A. S. Left Paratype	No. 11575 U. S. N. M. Left Paratype
Breadth of periotic at level of *fenestra ovalis* (from external face above excavation to internal face of *pars cochlearis*)	16.2	16.4	16.5
Greatest length of periotic (tip of anterior process to tip of posterior process)	26.9	26.5	26.6
Greatest dorso-ventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	9.7	9.9	10.4
Distance between *fenestra rotunda* and tip of anterior process	17.9	16.9	17.3
Distance between *fenestra rotunda* and tip of posterior process	13.9+	14.6+	13.9+
Distance between epitympanic orifice of *aquæductus Fallopii* and tip of anterior process	14.5	13.7	13.1